A 106.13:S-8
ISSN 0193-2853

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U.S. Department of Agriculture
Science and Education Administration
Agricultural Research Results • ARR-S-8/January 1981

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The author thanks W. T. Fox and other personnel of the University of Arkansas Rice Branch Experiment Station at Stuttgart and the Southeast Branch Experiment Station at Rohwer for their assistance in conducting these experiments. The following companies supplied experimental herbicides and part of the financial support for the research: Amchem Products, Inc.; BASF Wyandotte Corp.; Chevron Chemical Co.; Dow Chemical U.S.A.; Mobil Chemical Co.; Monsanto; PPG Industries, Inc.; Rhone Poulenc, Inc.; Rohm and Haas Co.; and Stauffer Chemical Co.

This research was conducted in cooperation with the University of Arkansas Agricultural Experiment Station.

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This publication is available from Science and Education Administration, U.S. Department of Agriculture, P.O. Box 287, Stuttgart, Ark. 72160.

Science and Education Administration, Agricultural Research Results, Southern Series, No. 8, January 1981.

Published by Agricultural Research (Southern Region), Science and Education Administration, U.S. Department of Agriculture, P.O. Box 53326, New Orleans, La. 70153.

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Herbicide Programs for Weed Control in Rice

By Roy J. Smith, Jr.[1]

ABSTRACT

This publication reports the results of research designed to compare the efficacy of new herbicide treatmens in controlling grass, aquatic, and broadleaf weeds in dry- and water-seeded rice. Herbicides were tested alone, in tank mixtures, and in sequential applications, and compared to standard herbicide treatments. Tests were conducted over several years at two locations in Arkansas, and weed control, crop injury, grain yield, head rice yield, and germination were determined for each treatment. Standard herbicides used in the research were propanil, molinate, and 2,4,5-T, and new herbicides tested were bentazon, bifenox, butachlor, butralin, nitrofluorfen, oxadiazon, oxyfluorfen, potassium azide, sodium azide, thiobencarb, and triclopyr. Index terms: aquatic weeds, broadleaf weeds, grass weeds, herbicides, rice, rice quality, rice seed germination, rice yields, weed control, weeds.

INTRODUCTION AND SUMMARY

Herbicides and cultural and mechanical practices are required to control weeds that reduce rice[2] quality and yields. In the United States in 1975-77, the total estimated direct losses from weeds and the cost of their control represented about 28% of the value of the crop annually (Smith et al. 1977, U.S. Department of Agriculture-States-U.S. Environmental Protection Agency 1979), or about $300 million per year.

About 80 species of weeds cause economic losses in rice in the United States (Smith et al. 1977). These species belong to about 40 genera classed as aquatic-semiaquatic plants. Some germinate only in flooded soil, some germinate in an upland environment but grow in flooded soil, and some can germinate and grow in either environment. Consequently, weed control technology must be effective on weeds that vary widely in their physical and physiochemical characteristics. The best approach to controlling weeds in U.S. rice is to use an integrated system that combines preventive, cultural, mechanical, chemical, and biological practices. Systems that omit any of these components are usually inadequate.

Cultural and mechanical practices are important components of weed control programs for rice, but herbicides are essential for a control system to be effective. Most U.S. rice is treated with herbicides each year; about 80% of it receives multiple herbicide treatments.

Because in the past two decades American rice has been treated only with herbicides with narrow ranges of chemical activity, weed species that compete with rice have shifted. Continued reliance on such herbicides as propanil,[3] molinate, 2,4,5-T,

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[2]For scientific names of plants mentioned in this publication, see the appendix.

[3]Chemical names of herbicides used in the experiments are given in table 1.

2,4-D,[4] and MCPA[5] has caused an increase in problems with weed species tolerant to them; species such as knotgrass, morningglory, panicum, pondweed, smartweed, sprangletop, spreading dayflower, umbrellasedge, and waterprimrose have increased in recent years. These hard-to-kill weeds are primary targets for research as are susceptible grass, broadleaf, and aquatic weeds that are not now controlled consistently.

This research was designed to compare the efficacy of new herbicide treatments (including new herbicides used alone or as components of herbicide programs) for control of grass, aquatic, and broadleaf weeds in dry- and water-seeded rice, and to determine the treatments' phytotoxicity to rice.

Weed Control in Dry-Seeded Rice

• Combination herbicide treatments consisting of tank mixtures or sequential applications of a herbicide with preemergence activity and another with postemergence activity controlled more species of weeds than single herbicide treatments, and effective control lasted longer than with standard treatments of propanil or molinate applied alone or combined. They controlled bearded and tighthead sprangletop, broadleaf weeds (eclipta, hemp sesbania, and spreading dayflower), and aquatic weeds (ducksalad, false pimpernel, redstem, and waterhyssop).

• Tank mixtures of propanil (a postemergence-active herbicide) with butachlor, oxadiazon, or thiobencarb (preemergence or residually active herbicides) consistently controlled the grass-aquatic-broadleaf weed complexes. Oxadiazon and thiobencarb exhibited some postemergence activity, but butachlor did not. These treatments frequently caused temporary crop injury (leaf chlorosis and inhibition of plant growth), but the rice usually recovered by midseason and produced satisfactory grain yield and quality. (Oxadiazon caused greater injury than butachlor or thiobencarb.) Because butachlor, oxadiazon, or thiobencarb gave residual control for 3 to 5 weeks after application, flooding immediately after treatment was not required to prevent reinfestation, but moisture provided by timely rains or irrigations was necessary to maintain preemergence activity.

• Tank mixtures of propanil and either bifenox or butralin performed unsatisfactorily.

• Sequential treatments that included bifenox, butachlor, oxadiazon, or thiobencarb applied preemergence followed by propanil or molinate applied postemergence controlled the grass-aquatic-broadleaf weed complexes. Although these preemergence-postemergence treatments performed less effectively than postemergence tank-mixture treatments, they performed better than standard treatments of propanil or molinate applied alone or combined. Sequential preemergence-postemergence treatments of butralin or oxyfluorfen followed by propanil were unsatisfactory.

• Sequential treatments that included standard postemergence applications of propanil or molinate followed by granular bifenox or thiobencarb controlled the grass-aquatic-broadleaf weed complexes. These treatments performed better than standard treatments of propanil or molinate (alone or combined), but they performed less effectively than the most active postemergence tank-mixture or preemergence-postemergence sequential treatments.

• Sequential treatments of propanil or molinate applied postemergence and followed by bentazon applied after emergence of aquatic weeds controlled barnyardgrass and the aquatics, but these treatments were ineffective on bearded sprangletop.

• Sequential postemergence treatments of propanil followed by granular nitrofluorfen or oxyfluorfen controlled barnyardgrass, spreading dayflower, and the aquatic weed complex, but failed to control bearded or tighthead sprangletop.

• Sequential treatments including a standard postemergence propanil application followed by triclopyr, or nitrofluorfen followed by a standard application of molinate performed unsatisfactorily; crop injury was too high and efficacy too low.

Weed Control in Water-Seeded Rice

• Single treatments of thiobencarb, tank mixtures of propanil and thiobencarb, and sequential treatments of propanil followed by thiobencarb, all applied early postemergence to water-seeded rice, controlled an aquatic weed complex of ducksalad, redstem, spikerush, and waterhyssop, and a grass-broadleaf weed complex of barnyardgrass, bearded sprangletop, broadleaf signalgrass, eclipta,

[4](2,4-Dichlorophenoxy)acetic acid.

[5][(4-Chloro-o-tolyl)oxy]acetic acid.

and spreading dayflower. These treatments controlled one- to four-leaf weeds and were safe on an established stand of rice (usually when plants were 8 to 15 cm tall). Thiobencarb alone, in mixtures, or in sequential treatments controlled weeds residually for up to 4 weeks after application. These treatments controlled the grass-aquatic-broadleaf weed complexes better than standard treatments of propanil or postemergence applications of tank mixtures of either propanil or molinate with 2,4,5-T or bentazon.

• A tank mixture of propanil and bentazon, applied early postemergence, consistently controlled redstem and waterhyssop, but gave inconsistent control of ducksalad. This mixture also controlled barnyardgrass, broadleaf signalgrass, eclipta, and spreading dayflower, but failed to control bearded sprangletop.

• Single treatments of granular potassium azide or sodium azide applied postemergence into the floodwater controlled aquatic weeds, and did not injure the rice.

MATERIALS AND METHODS

The experiments were conducted at the University of Arkansas Rice Branch Experiment Station at Stuttgart and the Southeast Branch Experiment Station at Rohwer, Ark., from 1973 through 1978. Five experiments comparing herbicide treatments in dry-seeded rice (experiments 1-5) were repeated for 2 or 3 years. Herbicide treatments were the same in experiments 2 and 3 except for slight rate adjustments for soil differences between Stuttgart and Rohwer. Three experiments with water-seeded rice (experiments 6-8) were repeated for 3 years at Stuttgart; herbicide treatments were similar within each experiment.

The herbicides used are listed in table 1. The formulations used in each treatment may be found by consulting table 1 or the tables that list results (tables 5-23, 25-27, 29-31). If only one form was used, it is shown in table 1 only. For herbicides used in more than one form, the emulsifiable concentrate form was used unless otherwise indicated in the results tables.

The effectiveness of numerous herbicide treatments in controlling the grass-aquatic-broadleaf weed complexes in dry- and water-seeded rice was tested. Combination treatments consisted of tank mixtures or sequential applications of a herbicide

Table 1.—Common and chemical names of herbicides and formulations applied in the experiments

Common name	Other designations	Chemical name	Formulation[1]
Bentazon	Basagran, BAS-3510	3-Isopropyl-1,*H*-2,1,3-benzothiadiazin-4(3*H*)-one-2,2-dioxide	EC
Bifenox	Modown, MC-4379	Methyl 5-(2,4-dichlorophenoxy)-2-nitrobenzoate	EC, Fl, G, WP
Butachlor	Machete, CP-53619	*N*-(Butoxymethyl)-2-chloro-2′6′-diethylacteanilide	EC
Butralin	Amex, A-820	4-(1,1-Dimethylethyl)-*N*-(1-methylpropyl)-2,6-dinitrobenzenamine	EC
Molinate	Ordram	*S*-Ethyl hexahydro-1*H*-azepine-1-carbothioate	EC, G
Nitrofluorfen	RH-2512	2-Chloro-1-(4-nitrophenoxy)-4-(trifluoromethyl)benzene	EC, G
Oxadiazon	Ronstar, RP-17623	2-*tert*-Butyl-4-(2,4-dichloro-5-isopropoxyphenyl)-Δ^2-1,3,4-oxadiazolin-5-one	EC
Oxyfluorfen	Goal, RH-2915	2-Chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene	EC, G
Potassium azide	Kazoe	Potassium azide	G
Propanil		3′,4′-Dichloropropionanilide	EC
Sodium azide	Smite	Sodium azide	G
Thiobencarb	Bolero, Saturn, IMC-3950	*S*-[(4-Chlorophenyl)methyl]diethylcarbamothioate	EC, G
Triclopyr[2]	Garlon, M-3724, Dowco 233	[(3,5,6-Trichloro-2-pyridinyl)oxy]acetic acid	WSL
2,4,5-T[3]		(2,4,5-Trichlorophenoxy)acetic acid	WSL

[1]EC, emulsifiable concentrate; Fl, flowable; G, granular; WP, wettable powder; WSL, water-soluble liquid.
[2]Triethylamine salt.
[3]Diethylamine salt.

Table 2.—Herbicide treatments tested on dry-seeded rice

Treatment	Time of treatment
Single herbicides:	
Bifenox[1]	Preemergence; postemergence.
Butachlor[1]	Preemergence.
Butralin[1]	Preemergence.
Molinate[2 3]	Postemergence.
Oxadiazon[1]	Preemergence.
Oxyfluorfen[1]	Preemergence.
Propanil[3]	Postemergence.
Thiobencarb[1]	Preemergence; postemergence.
Tank mixtures:	
Propanil + bifenox	Postemergence.
Propanil + butachlor	Postemergence.
Propanil + butralin	Postemergence.
Propanil + molinate	Postemergence.
Propanil + oxadiazon	Postemergence.
Propanil + thiobencarb	Postemergence.
Sequential treatments:	
Bifenox followed by molinate	Preemergence-postemergence; postemergence.
Bifenox followed by propanil	Preemergence-postemergence; postemergence.
Butachlor followed by molinate	Preemergence-postemergence.
Butachlor followed by propanil	Preemergence-postemergence.
Butralin followed by propanil	Preemergence-postemergence.
Molinate followed by bentazon[3]	Postemergence.
Molinate followed by bifenox	Postemergence.
Molinate followed by thiobencarb	Postemergence.
Nitrofluorfen[1 3] followed by molinate	Postemergence.
Oxadiazon followed by propanil	Preemergence-postemergence.
Oxyfluorfen followed by molinate	Preemergence-postemergence; postemergence.
Oxyfluorfen followed by propanil	Preemergence-postemergence.
Oxyfluorfen followed by thiobencarb	Preemergence; postemergence.
Propanil followed by bentazon	Postemergence.
Propanil followed by bifenox	Postemergence.
Propanil followed by molinate	Postemergence.
Propanil followed by nitrofluorfen	Postemergence.
Propanil followed by oxyfluorfen	Postemergence.
Propanil followed by propanil	Postemergence.
Propanil followed by thiobencarb	Postemergence.
Propanil followed by triclopyr[3]	Postemergence.
Propanil + molinate followed by molinate	Postemergence.
Thiobencarb followed by molinate	Preemergence-postemergence; postemergence.
Thiobencarb followed by propanil	Preemergence-postemergence; postemergence.

[1]Preemergence-active herbicide.
[2]Residually active herbicide.
[3]Postemergence-active herbicide.

with preemergence activity and another with postemergence activity. New treatments (using new herbicides or new combinations of old herbicides) were compared with single or sequential applications of standard herbicides (propanil, molinate, or 2,4,5-T) applied postemergence. The treatments tested are listed in tables 2 and 3.

Experiments were located on different sites each year, on which rice was managed in a rotation; one or two crops of soybeans were grown before the rice. Minimum herbicides were used on the soybean crop. Soil levees isolated each plot to prevent cross-contamination of plots with herbicides and to permit independent water management. Each plot had access to a canal to permit independent flooding and draining of irrigation water.

Analysis of variance and Duncan's multiple-range test were conducted separately for each year and location to compare averages of weed control, rice injury, grain yield, head rice (whole-grain

Table 3.—Herbicide treatments tested on water-seeded rice

Treatment	Time of treatment
Single herbicides:	
Bifenox[1]	Preplant.
Nitrofluorfen[1]	Preplant.
Potassium azide[2]	Postemergence.
Propanil[2]	Postemergence.
Sodium azide[2]	Postemergence.
Thiobencarb[1 2]	Postemergence.
2,4,5-T[2]	Postemergence.
Tank mixtures:	
Molinate[2 3] + bentazon[2]	Postemergence.
Molinate + 2,4,5-T	Postemergence.
Propanil + bentazon	Postemergence.
Propanil + thiobencarb	Postemergence.
Propanil + 2,4,5-T	Postemergence.
Sequential treatments:	
Bifenox followed by thiobencarb	Preplant-postemergence.
Nitrofluoren followed by thiobencarb	Preplant-postemergence.
Propanil followed by thiobencarb	Postemergence.

[1]Preemergence-active herbicide.
[2]Postemergence-active herbicide.
[3]Residually active herbicide.

milling) yield, and germination. In categorizing rice injury, less than 1% was considered none; 1% to 30%, slight; 31% to 70%, moderate; and 71% to 100%, severe. For weed control, less than 1% was considered none; 1% to 30%, poor; 31% to 70%, fair; 71% to 90%, good; and 91% to 100%, excellent. When a treatment's control of weeds was good to excellent, (greater than 71%) the weeds were considered "controlled."

Dry-Seeded Rice

Rice was drill-seeded on Crowley silt loam at Stuttgart and on Perry clay at Rohwer in April or May each year. 'Starbonnet' rice was seeded at Stuttgart in all years for each experiment; 'Starbonnet', 'Brazos', or 'Lebonnet' rice was seeded at Rohwer. Plots of about 35 m^2 were arranged in a randomized complete-block design with three replications per treatment in the Stuttgart experiments and four in the Rohwer experiments.

Nitrogen fertilizer was applied to all plots in three-way split applications at total rates of 112 to 168 kg/ha of N during the season. The first application was made about 3 weeks after rice emergence; the second, when the first elongating internodes on main culms of the plant averaged 1.3 cm for 'Starbonnet' and 'Brazos' and 1.9 cm for 'Lebonnet'; and the third, about 10 days after the second application. The nitrogen was applied directly into the floodwater, or floodwater was applied immediately after applying the nitrogen.

Barnyardgrass seeds were sown in Stuttgart plots, but there were natural infestations in the Rohwer plots. Natural infestations of sprangletop and aquatic and broadleaf weeds occurred in all plots.

Weed populations at both locations are listed in table 4. At Stuttgart there were moderate to heavy infestations of barnyardgrass, bearded sprangletop, spreading dayflower, and an aquatic weed complex of ducksalad, redstem, and waterhyssop; there was a light infestation of eclipta. False pimpernel infested experiment 4 plots during one year. At Rohwer there were moderate to heavy infestations of barnyardgrass, tighthead sprangletop, and the aquatic weed complex of ducksalad, redstem, and waterhyssop; there were light infestations of eclipta, hemp sesbania, and willowleaf morningglory.

Herbicides (table 1) were applied preemergence and at various times after emergence of rice and weeds. Treatments included applications of one herbicide, two applied sequentially or in tank mixtures or sequential application of tank mixtures and single herbicides. When herbicides with residual action were applied preemergence, they were applied after a rain or flush irrigation because

Table 4.—Populations of barnyardgrass, bearded sprangletop, and aquatic weeds in dry-seeded experiments at Stuttgart and Rohwer, 1974-78

Experiment, location, and weed	Weed population[1] (No./m²)				
	1974	1975	1976	1977	1978
Experiment 1 (Stuttgart):					
Barnyardgrass	129	86	118		
Aquatic weeds	540	50	0		
Experiment 2 (Stuttgart):					
Barnyardgrass		151	32		
Bearded sprangletop		0	54		
Aquatic weeds		540	540		
Experiment 2 (Rohwer):					
Barnyardgrass		86	108		
Aquatic weeds		1,100	430		
Experiment 3 (Stuttgart):					
Barnyardgrass				54	151
Bearded sprangletop				0	64
Aquatic weeds				650	54
Experiment 3 (Rohwer):					
Barnyardgrass					43
Aquatic weeds					750
Experiment 4 (Stuttgart):					
Barnyardgrass			64	22	97
Bearded sprangletop			20	0	86
Aquatic weeds			430	800	270
Experiment 5 (Stuttgart):					
Barnyardgrass			3	22	108
Bearded sprangletop			0	11	64
Aquatic weeds			860	700	540

[1]Barnyardgrass and bearded sprangletop panicles were counted and the number of aquatic weed plants was estimated. The principal aquatic weeds present were ducksalad, redstem, and waterhyssop.

delaying preemergence treatments until after the soil is wetted reduces injury to the rice crop.

Postemergence treatments (except molinate) were used mainly to control barnyardgrass, and were applied when the largest grass plants had two to four leaves (or were 2.5 to 8.0 cm tall, respectively). Postemergence treatments of granular molinate were applied when the largest grass plants had up to four leaves or were tillering (8 to 20 cm tall). Bearded and tighthead sprangletop were treated postemergence from the one-leaf to tillering stages (1.3 to 15 cm tall). Eclipta, hemp sesbania, spreading dayflower, and willowleaf morningglory were treated postemergence when they had from one to six leaves (1.3 to 20 cm tall). Aquatic weeds usually had not germinated at the time of preemergence treatments or the postemergence treatments applied before flooding. In cases where herbicide treatments were applied several days after permanent flooding, the aquatic weeds had emerged and had from one to six leaves (0.6 to 7.6 cm tall).

When barnyardgrass was in the two-leaf stage, rice had one to two leaves and ranged from 2.5 to 7.6 cm tall. When barnyardgrass was in the four-leaf stage, rice plants had from two to three leaves and were 7.6 to 15.2 cm tall. By the time aquatic weeds emerged, rice plants were in the early tillering stage, 15 to 30 cm tall.

Water management varied for the different herbicide treatments. Plots receiving standard treatments of propanil to control barnyardgrass in the four-leaf stage were flooded about 1 week after applying the propanil, after which, the floodwater was maintained. Plots receiving preemergence treatments or treatments to two-leaf barnyardgrass were flooded about 1 week after the propanil-treated plots. Plots receiving granular molinate treatments were flooded just before herbicide treatment and kept flooded thereafter. Plots receiving granular

applications of bifenox, nitrofluorfen, or thiobencarb were either drained at the time of application and flooded 1 or 2 days later or were flooded at time of application. All plots remained flooded after these early water management practices. Plots receiving treatments of triclopyr or bentazon were drained 1 or 2 days before application and were flooded again 1 or 2 days after application; they remained flooded thereafter.

Rice injury was estimated visually during early season (3 to 6 weeks after treatment in experiments 1 to 5) and again at midseason (6 to 9 weeks after treatments in experiments 4 and 5). Weed control was also estimated visually at the following times: barnyardgrass and bearded and tighthead sprangletop after panicles were present, usually in July or August; aquatic weeds after they began blooming, usually in July; spreading dayflower in September or October, about the time rice matured, when spreading dayflower plants grew above the rice canopy. Control of other weeds was estimated in July or August.

In untreated plots, the number of barnyardgrass and bearded sprangletop panicles was counted or estimated, and the number of aquatic weed plants was estimated. Untreated plots were used as a basis for evaluating the performance of treatments on all weeds except aquatics (the aquatic weed complex frequently failed to grow well in untreated plots where populations of barnyardgrass, sprangletop, and broadleaf weeds shaded the water). Since molinate or propanil applied before aquatic weeds germinate usually fails to control the aquatic weed complex (Smith 1977a), plots treated thus were often used as a comparison to evaluate the performance of other treatments in controlling of aquatic weeds.

In all experiments, center rows of mature rice were harvested with a small-plot combine or hand-harvested and threshed with a nursery-type thresher. The area harvested was about 5 m^2. Rough rice yields were based on grain weights adjusted to 12% moisture. Rough rice samples from each plot were cleaned and milled as described by Adair et al. (1973). Head rice (whole-grain milling) yields were obtained by milling samples that contained about 12% moisture. Duplicate samples of 100 rice grains from each plot were germinated (by standard procedures) in rolled moist paper in controlled temperature and humidity to determine if herbicide treatments affected seed viability.

Water-Seeded Rice

'Starbonnet' rice was water-seeded in late April or early May each year on Crowley silt loam. Herbicide-water sprays were applied to drained plots, and granular formulations were applied into the floodwater. Plots about 35 m^2 were arranged in randomized complete blocks with three replications of each treatment. Nitrogen fertilizer was applied as previously described at a total rate of 123 to 146 kg/ha.

In experiment 6, herbicide treatments were applied postemergence 10 to 20 days after seeding. In experiment 7, single herbicide treatments were applied before plots were flooded and seeded, or single and sequential herbicide treatments were applied preplant or postemergence 10 to 25 days after seeding. In experiment 8, herbicide treatments were applied postemergence 15 to 35 days after seeding. There were moderate to heavy infestations (540 to 1,519 plants/m^2) of aquatic weeds in the plots in all three experiments. Bearded sprangletop infestations in experiment 8 were light to heavy, or 25, 11, and 74 panicles/m^2 in 1976, 1977, and 1978, respectively.

In all experiments a measured center area of about 5 m^2 of matured rice was harvested from each plot as described previously. Grain yields, head rice milling yields, and germination of rice seeds were determined by the procedures described previously.

RESULTS

Dry-Seeded Rice

Weed species and the intensity of their infestations in the plots varied among years and locations (table 2) because of differences in soil texture, soil moisture and fertility, floodwater management, and crop stand.

Experiment 1

Barnyardgrass infested all plots in all years (tables 4, 5-7). Aquatic weeds infested all plots in 1974 and 1975, but in 1976 they occurred at insufficient levels for a valid evaluation. Spreading dayflower was present only in 1975.

(*Continued on page 11.*)

Table 5.—Experiment 1 (Stuttgart, 1974): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)		Injury (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
				Barnyard-grass	Aquatic weeds[5]				
Propanil	3.4	Postemergence (2-leaf)	D	88b	30bc	0c	5,412a	56	93
Propanil[7]	4.5	Postemergence (4-leaf)	D	100a	0c	7bc	5,293a	56	96
Molinate (G)[7]	3.4	Postemergence (4-leaf)	F	100a	0c	20ab	5,323a	59	92
Propanil followed by propanil.[7]	3.4; 3.4	Postemergence (2-leaf); postemergence (4-leaf).	D; D	100a	30bc	7bc	5,573a	55	93
Propanil followed by molinate (G).	3.4; 3.4	Postemergence (2-leaf); 1 day after flooding.	D; F	100a	33b	7bc	4,861a	57	95
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	100a	97a	0c	5,589a	57	93
Propanil followed by bifenox (G).	4.5; 2.2	Postemergence (4-leaf); 1 day before flooding.	D; D	100a	100a	0c	5,095a	56	90
Propanil followed by bifenox (G).	4.5; 3.4	Postemergence (4-leaf); 5 days after flooding.	D; F	100a	100a	10bc	5,142a	54	95
Propanil followed by nitrofluorfen (G).	4.5; 0.28	Postemergence (4-leaf); 1 day before flooding.	D; D	99a	98a	0c	4,960a	53	94
Propanil followed by nitrofluorfen (G).	4.5; 0.56	Postemergence (4-leaf) 1 day before flooding.	D; D	98a	100a	7bc	5,056a	56	92
Propanil followed by thiobencarb (G).	4.5; 3.4	Postemergence (4-leaf) 5 days after flooding.	D; F	100a	100a	0c	4,986a	57	94
Molinate (G) followed by bifenox (G).	3.4; 3.4	Postemergence (4-leaf) 5 days after flooding.	F; F	100a	100a	20ab	5,093a	54	95
Molinate (G) followed by thiobencarb (G).	3.4; 3.4	Postemergence (4-leaf) 5 days after flooding.	F; F	100a	100a	27a	5,469a	55	94
Nitrofluorfen (G) followed by molinate (G).	0.28; 3.4	Postemergence (4-leaf) 1 day after flooding.	D; F	100a	93a	30a	5,312a	54	93
Nitrofluorfen (G) followed by molinate (G).	0.56; 3.4	Postemergence (4-leaf) 1 day after flooding.	D; F	100a	99a	30a	5,189a	54	94
None				0c	95a	0c	1,472b	52	93

[1]'Starbonnet' rice drill-seeded April 29, emerged May 9. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast; other herbicides were applied in water sprays.

[3]Leaf number given for barnyardgrass.

[4]Floodwater condition at time of treatment; D, drained; F, flooded.

[5]Ducksalad, redstem, and waterhyssop.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

Table 6.—Experiment 1 (Stuttgart, 1975): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
				Barnyard grass	Aquatic weeds[5]	Spreading dayflower				
Propanil	3.4	Postemergence (2-leaf)	D	88c	0c	7d	0b	6,409b	61	93
Propanil[7]	4.5	Postemergence (4-leaf)	D	100a	0c	95ab	0b	7,171ab	61	92
Molinate[7] (G)	3.4	Postemergence (4-leaf)	F	100a	7bc	73c	0b	7,123ab	61	93
Propanil followed by propanil[7].	3.4; 3.4	Postemergence (2-leaf); postemergence (4-leaf).	D; D	100a	17bc	87b	0b	7,254ab	60	97
Propanil followed by molinate (G).	3.4; 3.4	Postemergence (2-leaf); 1 day after flooding.	D; F	92b	10bc	3d	7b	6,953ab	61	95
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	100a	27b	90ab	0b	7,596a	62	96
Propanil followed by bifenox (G).	4.5; 2.2	Postemergence (4-leaf); 1 day before flooding.	D; D	100a	95a	100a	0b	7,614a	62	94
Propanil followed by bifenox (G).	4.5; 3.4	Postemergence (4-leaf); 5 days after flooding.	D; F	98a	95a	100a	0b	7,328a	59	95
Propanil followed by nitrofluorfen (G).	4.5; 0.28	Postemergence (4-leaf); 1 day before flooding.	D; D	100a	95a	100a	17a	7,913a	61	95
Propanil followed by nitrofluorfen (G).	4.5; 0.56	Postemergence (4-leaf); 1 day before flooding.	D; D	100a	93a	100a	40a	7,429a	61	95
Propanil followed by thiobencarb (G).	4.5; 3.4	Postemergence (4-leaf); 5 days after flooding.	D; F	100a	95a	100a	0b	7,246ab	62	97
Molinate (G) followed by bifenox (G).	3.4; 3.4	Postemergence (4-leaf); 5 days after flooding.	F; F	100a	95a	100a	7b	7,579a	59	96
Molinate (G) followed by thiobencarb (G).	3.4; 3.4	Postemergence (4-leaf); 5 days after flooding.	F; F	100a	93a	100a	10b	7,512a	61	94
Nitrofluorfen (G) followed by molinate (G).	0.28; 3.4	Postemergence (4-leaf); 1 day after flooding.	D; F	100a	93a	100a	23a	7,338a	60	93
Nitrofluorfen (G) followed by molinate (G).	0.56; 3.4	Postemergence (4-leaf); 1 day after flooding.	D; F	100a	93a	100a	47a	7,476a	62	94
None				0d	7bc	0d	0b	4,539c	61	89

[1] 'Starbonnet' rice drill-seeded April 24, emerged May 4. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] Granular herbicides (G) were broadcast; other herbicides were applied in water sprays.

[3] Leaf number given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Ducksalad, redstem, and waterhyssop.

[6] No values are significantly different (at the 5% level).

[7] Standard herbicide treatment.

Table 7.—Experiment 1 (Stuttgart, 1976): influence of herbicide treatment on barnyardgrass control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Barnyardgrass control (%)	Injury (%)	Grain yield (kg/ha)	Germination[5] (%)
Propanil	3.4	Postemergence (2-leaf)	D	43b	0	6,373b	97
Propanil[6]	4.5	Postemergence (4-leaf)	D	100a	0	8,109a	97
Molinate (G)[6]	3.4	Postemergence (4-leaf)	F	99a	0	7,834a	98
Propanil followed by propanil[6]	3.4; 3.4	Postemergence (2-leaf); postemergence (4-leaf).	D; D	100a	0	7,930a	98
Propanil followed by molinate (G)	3.4; 3.4	Postemergence (2-leaf); 1 day after flooding.	D; F	100a	0	7,755a	98
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf);	D;	100a	0	7,989a	97
Propanil followed by bifenox (G)	4.5; 2.2	Postemergence (4-leaf); 1 day before flooding.	D; D	100a	0	8,005a	96
Propanil followed by bifenox (G)	4.5; 3.4	Postemergence (4-leaf); 5 days after flooding.	D; F	100a	0	8,176a	97
Propanil followed by thiobencarb (G)	4.5; 3.4	Postemergence (4-leaf); 5 days after flooding.	D; F	100a	0	7,992a	98
Molinate followed by bifenox (G)	3.4; 3.4	Postemergence (4-leaf); 5 days after flooding.	F; F	94a	0	7,637a	98
Molinate (G) followed by thiobencarb (G)	3.4; 3.4	Postemergence (4-leaf); 5 days after flooding.	F; F	100a	0	7,965a	98
None				0c	0	1,931c	98

[1]'Starbonnet' rice drill-seeded May 12, emerged May 23. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast; other herbicides were applied in water sprays.

[3]Leaf number given for barnyardgrass.

[4]Floodwater condition at time of treatment: D, drained; F, flooded.

[5]No values are significantly different (at the 5% level).

[6]Standard herbicide treatment.

None of the treatments injured rice plants excessively, but in some years, some treatments injured rice more than others. In 1974 and 1975, nitrofluorfen (applied before flooding) followed by molinate (applied after flooding) injured rice more than standard treatments of propanil. In 1975 nitrofluorfen followed by molinate caused more injury than standard treatments of molinate, and the higher rate of nitrofluorfen (0.56 kg/ha) injured rice more than the lower rate (0.28 kg/ha). Also in 1975, nitrofluorfen applied at 0.56 kg/ha after propanil injured rice moderately and significantly more than either propanil or molinate alone, but the rice recovered from the early injury by midseason (50 to 70 days after seeding). Nitrofluorfen was dropped from the test in 1976 because of the injury it caused rice in 1974 and 1975. Over the entire 3-year period, little or no rice injury was observed with tank mixtures of propanil and thiobencarb or sequential treatments of propanil or molinate followed by granular applications of bifenox or thiobencarb.

All herbicide treatments controlled weeds sufficiently to increase grain yields significantly over untreated plots. Standard treatments of propanil or molinate (applied when barnyardgrass was at the four-leaf stage) controlled barnyardgrass effectively all 3 years, but failed to control aquatic weeds. They gave good to excellent control of spreading dayflower in 1975, the only year this weed was present. Propanil controlled two-leaf barnyardgrass, but many grass plants emerged after treatment to reinfest the plots; in 1975 and 1976 this reduced grain yields compared with the best performing treatments. This treatment also failed to control aquatic weeds and spreading dayflower.

Sequential applications of propanil controlled barnyardgrass all 3 years and controlled spreading dayflower in 1975. And although this treatment controlled aquatic weeds poorly, the aquatic weeds did not compete with the crop enough to reduce grain yields.

A sequential application of propanil applied early postemergence followed by granular molinate applied after flooding controlled barnyardgrass effectively all 3 years, but gave poor control of aquatic weeds and spreading dayflower. Rice receiving this treatment yielded well.

A tank mixture of propanil and thiobencarb controlled barnyardgrass all 3 years and spreading dayflower in 1975. It gave excellent control of aquatic weeds in 1974, but poor control in 1975. Rice receiving this treatment yielded well.

Sequential applications of either propanil or molinate followed by granular bifenox or thiobencarb controlled barnyardgrass, spreading dayflower, and the aquatic weed complex in all years. These treatments controlled the aquatic weeds especially well (better than the standard treatments of propanil or molinate), and they also controlled the grass-aquatic-broadleaf weed complexes better than standard treatments. Rice receiving these sequential treatments yielded well.

Rice quality was not affected by any of the treatments; head rice yield and seed germination were excellent for rice from all treatments.

Experiment 2

Stuttgart.—Barnyardgrass and aquatic weeds infested the plots in both years (tables 4, 8-9), and there were infestations of spreading dayflower in 1975 and bearded sprangletop in 1976.

All herbicide treatments controlled weeds well enough to increase grain yields compared with no weeding. Some of the treatments injured rice more than others, but injury was only slight to moderate from any one treatment. Many of the treatments injured rice more in 1976 than in 1975. Herbicides applied preemergence (alone or sequentially with propanil) injured rice slightly to moderately, and tank mixtures of some herbicides injured rice moderately, but the crop usually recovered from this early injury by midseason (50 to 70 days after seeding).

Propanil, applied to two-leaf barnyardgrass, controlled the weeds present, but more grass plants emerged after treatment to reinfest the plots and lower grain yields (compared to yields from plots given standard treatments of propanil or molinate). Heavy barnyardgrass infestations in the early propanil treatment inhibited aquatic weed development in 1975, but infestations of barnyardgrass and bearded sprangletop did not inhibit the aquatics in 1976.

Standard treatments of propanil and molinate controlled four-leaf and tillering barnyardgrass, respectively, and standard water management practices of flooding about 1 week after treatment prevented reinfestations of barnyardgrass, but these treatments did not prevent aquatic weeds

(*Continued on page 14.*)

Table 8.—Experiment 2 (Stuttgart, 1975): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination (%)
				Barnyard-grass	Aquatic weeds[5]	Spreading dayflower				
Thiobencarb	4.5	Preemergence	D	92a	47de	60b	0c	6,699ab	61	85ab
Oxadiazon	0.84	Preemergence	D	90a	95a	57b	7bc	6,334abc	62	87ab
Bifenox (WP)	3.4	Preemergence	D	43d	78abc	53b	7bc	5,499c	59	83ab
Butralin	3.4	Preemergence	D	73b	53cde	13cd	27a	5,732bc	60	88a
Propanil	3.4	Postemergence (2-leaf)	D	60c	27e	13cd	0c	5,260c	58	85ab
Propanil[7]	4.5	Postemergence (4-leaf)	D	92a	0f	93a	0c	7,010a	61	86ab
Molinate (G)[7]	3.4	Postemergence (tillering)	F	94a	7f	53b	10bc	6,754ab	62	85ab
Thiobencarb followed by propanil.	4.5; 3.4	Preemergence; postemergence (4-leaf).	D; D	95a	77abc	83a	0c	6,884ab	60	88a
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence; postemergence (4-leaf).	D; D	93a	87ab	60b	0c	6,386abc	62	85ab
Bifenox (WP) followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	88a	95a	89a	7bc	6,971ab	62	86ab
Butralin followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	91a	37de	33c	7bc	6,971ab	63	86ab
Thiobencarb	4.5	Postemergence (2-leaf)	D	88a	85ab	92a	0c	6,896ab	61	86ab
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	98a	40de	95a	0c	6,825ab	62	87ab
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf)	D	99a	95a	83a	0c	6,999ab	60	88a
Propanil + bifenox (WP)	3.4+2.2	Postemergence (2-leaf)	D	23e	53cde	30c	0c	4,135d	58	80ab
Propanil + butralin	3.4+3.4	Postemergence (2-leaf)	D	93a	60bcd	17cd	0c	6,682ab	63	86ab
Propanil + molinate	3.4+3.4	Postemergence (4-leaf)	D	93a	10f	97a	0c	7,189a	60	86ab
Propanil followed by thiobencarb (G).	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	100a	95a	100a	0c	6,890ab	61	87ab
Propanil followed by bifenox (G).	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	93a	95a	100a	7bc	7,076a	60	86ab
Molinate (G) followed by thiobencarb (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	100a	95a	83a	10bc	6,901ab	62	86ab
Molinate (G) followed by bifenox (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	99a	95a	100a	17ab	7,082a	58	88a
None				0f	65bcd	0d	0c	1,872e	57	70c

[1] 'Starbonnet' rice drill-seeded April 24, emerged May 4. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] G, granular; WP, wettable powder. Granular herbicides were broadcast; others were applied in water sprays.

[3] Growth stage given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Ducksalad, redstem, and waterhyssop.

[6] No values are significantly different (at the 5% level).

[7] Standard herbicide treatment.

Table 9.—Experiment 2 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
				Barnyardgrass	Bearded sprangletop	Aquatic weeds[5]				
Thiobencarb	4.5	Preemergence	D	98a	97ab*	63c	27cd	7,638a	63	98
Oxadiazon	0.84	Preemergence	D	100a	98a	96a	33bc	7,394a	64	97
Bifenox (WP)	3.4	Preemergence	D	94a	96ab	52d	40a	7,658a	64	99
Butralin	3.4	Preemergence	D	100a	96ab	17g	33bc	7,372ab	64	98
Propanil	3.4	Postemergence (2-leaf)	D	77b	50d	0h	7e	6,217b	67	97
Propanil[7]	4.5	Postemergence (4-leaf)	D	98a	78bc	0h	0f	7,112ab	64	98
Molinate (G)[7]	3.4	Postemergence (tillering)	F	100a	50d	0h	0f	7,086ab	65	99
Thiobencarb followed by propanil.	4.5; 3.4	Preemergence; postemergence (4-leaf).	D; D	99a	98a	50d	30c	7,332ab	67	97
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence; postemergence (4-leaf).	D; D	100a	97ab	95a	40a	7,714a	65	99
Bifenox (WP) followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	100a	97ab	67c	40a	7,898a	66	97
Butralin followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	100a	97ab	30f	33bc	7,550a	66	97
Thiobencarb	4.5	Postemergence (2-leaf)	D	99a	98a	63c	23d	7,390a	65	98
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	100a	98a	67c	27cd	7,291ab	63	98
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf)	D	100a	87abc	95a	40a	7,720a	65	97
Propanil + bifenox (WP)	3.4+2.2	Postemergence (2-leaf)	D	95a	75c	78b	37ab	7,363ab	63	98
Propanil + butralin	3.4+3.4	Postemergence (2-leaf)	D	96a	95ab	37e	27cd	7,230ab	64	97
Propanil + molinate	3.4+3.4	Postemergence (4-leaf)	D	98a	78bc	0h	0f	6,702ab	65	98
Propanil followed by thiobencarb (G).	4.5; 2.2	Postemergence (4-leaf) 5 days after flooding.	D; F	100a	95ab	100a	0f	7,673a	66	97
Propanil followed by bifenox (G).	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	100a	75c	100a	0f	7,284ab	65	99
Molinate (G) followed by thiobencarb (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	100a	88abc	100a	0f	7,730a	65	96
Molinate (G) followed by bifenox (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	100a	52d	100a	0f	7,586a	65	98
None				0c	0e	0h	0f	4,958c	66	98

[1] 'Starbonnet' rice drill-seeded April 28, emerged May 14. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] G, granular; WP, wettable powder. Granular herbicides were broadcast; others were applied in water sprays.

[3] Growth stage given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Ducksalad, redstem, and waterhyssop.

[6] No values are significantly different (at the 5% level).

[7] Standard herbicide treatment.

from germinating after flooding. The standard propanil treatment controlled spreading dayflower, but the standard molinate treatment gave partial control.

Preemergence treatments of thiobencarb or oxadiazon controlled barnyardgrass and bearded sprangletop. Oxadiazon controlled the aquatic weed complex, but thiobencarb only gave partial control. Bifenox applied preemergence gave excellent control of barnyardgrass in 1976 and fair control in 1975. It gave excellent control of bearded sprangletop, fair to good control of aquatic weeds, and fair control of spreading dayflower. Butralin, applied preemergence, gave good to excellent control of barnyardgrass and bearded sprangletop, poor to fair control of aquatic weeds, and poor control of spreading dayflower.

When a standard postemergence propanil treatment followed preemergence applications of thiobencarb, oxadiazon, bifenox, or butralin, overall weed control was improved over single preemergence treatments of these herbicides. Good to excellent control of barnyardgrass and bearded sprangletop was obtained, but added propanil did not usually increase control of aquatic weeds.

A postemergence application of thiobencarb alone controlled barnyardgrass, bearded sprangletop, and spreading dayflower. It gave good control of aquatic weeds in 1975 and fair control in 1976.

Applications of tank mixtures applied postemergence at barnyardgrass' two-leaf stage usually controlled the weed complex better than standard postemergence treatments or preemergence treatments of single herbicides. Propanil and oxadiazon controlled barnyardgrass, bearded sprangletop, aquatic weeds, and spreading dayflower. Propanil and thiobencarb controlled barnyardgrass, bearded sprangletop, and spreading dayflower, and gave partial control of aquatic weeds both years. Propanil and bifenox controlled barnyardgrass, bearded sprangletop, and aquatic weeds in 1976, but they failed to control barnyardgrass, aquatics, or spreading dayflower in 1975. Propanil and butralin controlled barnyardgrass and bearded sprangletop, and gave partial control of aquatic weeds and spreading dayflower. A propanil and molinate tank mixture applied postemergence at barnyardgrass' four-leaf stage controlled barnyardgrass, bearded sprangletop, and spreading dayflower but failed to control aquatic weeds.

Propanil or molinate applied postemergence followed by granular applications of thiobencarb or bifenox controlled barnyardgrass, aquatic weeds, and spreading dayflower. Postemergence applications of propanil, followed by granular thiobencarb or bifenox, and postemergence applications of molinate, followed by granular thiobencarb, controlled bearded sprangletop, but postemergence applications of molinate followed by granular bifenox gave only partial control of this grass weed.

Generally, rice receiving treatments that gave effective control of the weed complexes produced the highest grain yields. Barnyardgrass and bearded sprangletop were more competitive with rice than aquatic weeds or spreading dayflower; rice receiving treatments that gave poor control of these two grass weeds frequently had significantly reduced yields.

Rice quality was not affected by any herbicide treatment; head rice yields were excellent with rice from all treatments. In 1975 seed harvested from treated rice germinated better than seed harvested from untreated rice, but the treatments did not affect germination in 1976. Apparently, competition from weeds reduced seed viability in 1975.

Rohwer.—In 1975 and 1976, Rohwer study plots were infested with barnyardgrass, aquatic weeds, and eclipta; in 1976, they were also infested with hemp sesbania and willowleaf morningglory (tables 4, 10-11).

In 1975, all herbicide treatments controlled weeds well enough to increase rice yields over unweeded plots, but yield differences among treatments were not as great in 1976 as in 1975. Standard treatments of propanil or molinate controlled barnyardgrass but did not control aquatic weeds. Propanil controlled eclipta, hemp sesbania, and willowleaf morningglory, but molinate did not. Early treatments of propanil controlled two-leaf barnyardgrass in 1975 but not 1976. Evidently, in 1975 all barnyardgrass had emerged by the time the two-leaf treatments were applied. Early propanil treatments (applied at barnyardgrass' two-leaf stage) controlled eclipta but failed to control the aquatic weed complex and willowleaf morningglory.

Thiobencarb, oxadiazon, bifenox, and butralin applied preemergence controlled barnyardgrass both years. Control of other weeds varied with treatment and year. Oxadiazon and bifenox controlled aquatic weeds both years. Thiobencarb gave excellent control of aquatics in 1975 and fair control in 1976. Butralin gave poor to fair control of aquatic weeds. Thiobencarb gave good control of eclipta in 1975, as did bifenox in 1976; both controlled hemp sesbania in 1976. Both oxadiazon

Table 10. — Experiment 2 (Rohwer, 1975): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination (%)
				Barnyard-grass	Aquatic weeds[5]	Eclipta				
Thiobencarb	4.5	Preemergence	D	94a	92a	89a	0	4,678abc	62	90ab
Oxadiazon	0.84	Preemergence	D	95a	92a	42de	0	5,177a	61	90ab
Bifenox (WP)	3.4	Preemergence	D	75b	78ab	55cd	0	4,161c	60	87bcd
Butralin	3.4	Preemergence	D	95a	62bcd	42de	0	4,554abc	60	82e
Propanil	3.4	Postemergence (2-leaf)	D	91a	0e	94a	0	4,461abc	60	87bcd
Propanil [7]	4.5	Postemergence (4-leaf)	D	94a	0e	95a	0	4,078c	61	89abc
Molinate (G)[7]	3.4	Postemergence (tillering)	F	85ab	0e	22ef	0	4,362bc	61	86cd
Thiobencarb followed by propanil.	4.5; 3.4	Preemergence; postemergence (4-leaf).	D; D	95a	70b	95a	0	4,805abc	60	81e
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence; postemergence (4-leaf).	D; D	95a	95a	95a	0	5,128ab	60	88abc
Bifenox (WP) followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	95a	68bc	95a	0	4,560abc	61	90ab
Butralin followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	95a	50d	66bc	0	4,978abc	61	88abc
Thiobencarb	4.5	Postemergence (2-leaf)	D	86ab	92a	85ab	0	4,713abc	61	84de
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	95a	91a	95a	0	5,008ab	62	90ab
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf)	D	94a	95a	95a	0	4,834abc	62	89abc
Propanil + bifenox (WP)	3.4+2.2	Postemergence (2-leaf)	D	91a	94a	95a	0	4,725abc	62	92a
Propanil + butralin	3.4+3.4	Postemergence (2-leaf)	D	95a	60cd	95a	0	4,816abc	60	89abc
Propanil + molinate	3.4+3.4	Postemergence (4-leaf)	D	95a	0e	95a	10	4,673abc	60	81e
Propanil followed by thiobencarb (G).	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	95a	95a	95a	0	4,870abc	61	86cd
Propanil followed by bifenox (G).	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	88a	95a	89a	0	4,578abc	62	86cd
Molinate (G) followed by thiobencarb (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	92a	95a	15fg	0	4,666abc	64	84de
Molinate (G) followed by bifenox (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	90a	89a	20fg	18	4,408abc	60	86cd
None				0c	0e	0g	0	2,794d	58	86cd

[1] 'Brazos' rice drill-seeded May 14, emerged May 24. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] G, granular; WP, wettable powder. Granular herbicides were broadcast; others were applied in water sprays.

[3] Growth stage given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Ducksalad, redstem, and waterhyssop.

[6] No values are significantly different (at the 5% level).

[7] Standard herbicide treatment.

Table 11. — Experiment 2 (Rohwer, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)					Injury (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
				Barnyardgrass	Aquatic weeds[5]	Eclipta	Hemp sesbania	Willowleaf morningglory				
Thiobencarb	4.5	Preemergence	D	97abc	60bc	55bcd	72abc	28cd	0	4,684abcd	67	99
Oxadiazon	0.84	Preemergence	D	82efdh	79abc	30def	38cde	98a	0	4,656abcd	66	98
Bifenox (WP)	3.4	Preemergence	D	85defg	86ab	86ab	88a	91ab	0	4,387abcd	65	98
Butralin	3.4	Preemergence	D	94abcd	0e	0f	10e	52abc	0	4,572abcd	64	98
Propanil	3.4	Postemergence (2-leaf)	D	74h	0e	100a	90a	35cd	0	4,218abcd	66	99
Propanil[7]	4.5	Postemergence (4-leaf)	D	89bcdf	0e	97a	100a	72abc	0	4,761abcd	66	97
Molinate (G)[7]	3.4	Postemergence (tillering)	F	88cdefg	24d	25def	25e	32cd	0	4,022abcd	66	98
Thiobencarb followed by propanil.	4.5; 3.4	Preemergence; postemergence (4-leaf).	D; D	98ab	55c	91a	100a	81abc	0	4,959abc	67	98
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence; postemergence (4-leaf).	D; D	96abc	90a	89a	99a	100a	0	5,480a	64	97
Bifenox (WP) followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	97abc	76abc	100a	100a	96a	0	5,096ab	66	98
Butralin followed by propanil.	3.4; 3.4	Preemergence; postemergence (4-leaf).	D; D	100a	0e	98a	100a	91ab	0	4,858abcd	65	97
Thiobencarb	4.5	Postemergence (2-leaf)	D	95abc	75abc	70abc	85ab	68abc	0	5,006ab	67	98
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	100a	81abc	100a	88a	92ab	0	4,997ab	70	99
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf)	D	92abcd	72abc	74abc	72abc	74abc	0	4,125abcd	66	98
Propanil + bifenox	3.4+2.2	Postemergence (4-leaf)	D	95abc	84ab	100a	100a	100a	0	5,192ab	66	98
Propanil + butralin	3.4+3.4	Postemergence (4-leaf)	D	94abcd	0e	99a	70abcd	49abcd	0	4,792abcd	66	97
Propanil + molinate	3.4+3.4	Postemergence (4-leaf)	D	80fgh	0e	97a	100a	55abc	0	4,561abcd	66	98
Propanil followed by thiobencarb.	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	79gh	78abc	85ab	98a	58abc	0	4,885abcd	64	98
Propanil followed by bifenox.	4.5; 2.2	Postemergence (4-leaf); 5 days after flooding.	D; F	80fgh	89a	98a	100a	62abc	0	4,526abcd	67	98
Molinate (G) followed by thiobencarb.	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	92abcd	91a	50cde	68abcd	60abc	0	4,310abcd	68	99
Molinate (G) followed by bifenox (G).	3.4; 2.2	Postemergence (tillering); 5 days after flooding.	F; F	91abcde	88a	18ef	40bcde	42bcd	0	3,569bcd	66	98
None				0i	0e	0f	12e	0d	0	3,139d	65	98

[1]'Starbonnet' rice drill-seeded April 16, emerged May 15. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]G, granular; WP, wettable powder. Granular herbicides were broadcast, others were applied in water sprays.

[3]Growth stage given for barnyardgrass.

[4]Floodwater condition at time of treatment; D, drained; F, flooded.

[5]Ducksalad, redstem, and waterhyssop.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

and bifenox controlled willowleaf morningglory in 1976.

Propanil applied postemergence following preemergence applications of thiobencarb, oxadiazon, bifenox, or butralin usually improved control of the weeds compared with preemergence applications alone or a standard propanil treatment. All sequential treatments controlled barnyardgrass both years, and hemp sesbania and willowleaf morningglory in 1976. The components applied preemergence in sequential treatments gave varying control of aquatic weeds that germinated after flooding both years; bifenox gave fair to good residual control, thiobencarb fair control, and butralin poor to fair control. Thiobencarb, oxadiazon, or bifenox followed by propanil gave good to excellent control of eclipta. Butralin followed by propanil gave excellent control of eclipta in 1976 but only fair control in 1975. Plots treated with preemergence applications of herbicides and postemergence applications of propanil yielded well.

Early postemergence applications (two-leaf stage) of thiobencarb alone controlled the weeds better than standard treatments of propanil or molinate alone. Plots given these early postemergence treatments yielded well.

Tank mixtures combining thiobencarb, oxadiazon, or bifenox with propanil, applied early postemergence, controlled barnyardgrass, aquatic weeds, eclipta, hemp sesbania, and willowleaf morningglory. A propanil-butralin treatment controlled barnyardgrass and eclipta both years, but gave unsatisfactory control of aquatic weeds and willowleaf morningglory. Rice treated with tank mixtures yielded well.

A tank mixture of propanil and molinate controlled barnyardgrass, eclipta, and hemp sesbania. Although this mixture failed to control aquatics and willowleaf morningglory, the rice receiving it yielded well because the aquatic weeds and willowleaf morningglory infestations were insufficient to reduce grain yields.

Conventional treatments of propanil or molinate followed by granular thiobencarb or bifenox applied into the floodwater controlled barnyardgrass and the aquatic weed complex. Germinated aquatics were killed by thiobencarb and bifenox; emerged eclipta and hemp sesbania were controlled by propanil but not by postemergence granular treatments of molinate, thiobencarb, or bifenox applied into the floodwater. These sequential treatments also gave fair control of willowleaf morningglory, and rice receiving these treatments yielded well.

No herbicide treatment injured rice significantly, and none significantly reduced milling quality (head rice yield) in either year, or seed germination in 1976. Some differences in seed germination occurred as a result of some 1975 treatments, but all seed germinated well (more than 80%).

Experiment 3

Stuttgart.—Plots were infested with barnyardgrass in 1977 and 1978, aquatic weeds and spreading dayflower in 1977, and bearded sprangletop in 1978 (tables 4, 12-13).

All herbicide treatments controlled weeds well enough to increase grain yields significantly over unweeded plots. Some herbicide treatments injured rice slightly more in 1977 than in 1978, but the injury was temporary, because the rice recovered from the injury by mid to late season (50 to 100 days after crop emergence) and produced good grain yields.

Standard treatments of propanil or molinate gave good to excellent control of barnyardgrass, but only poor to fair control of aquatic weeds and bearded sprangletop. Propanil controlled spreading dayflower, but molinate did not. In 1977, weed competition in the molinate treatment reduced grain yields compared with the best performing treatments.

Propanil applied at the two-leaf stage gave good control of barnyardgrass in 1977, but poor control in 1978 (it controlled two-leaf grass plants, but plots were reinfested later). It gave poor to fair control of bearded sprangletop and spreading dayflower and little, if any, control of aquatic weeds. Weed competition with rice receiving this treatment reduced grain yields in 1978 but not in 1977.

Preemergence treatments of thiobencarb controlled barnyardgrass, aquatic weeds, spreading dayflower, and bearded sprangletop, and plots so treated yielded well. Bifenox applied preemergence controlled barnyardgrass, aquatic weeds, and spreading dayflower in 1977, but it failed to control barnyardgrass or bearded sprangletop in 1978, resulting in a lowered grain yield in 1978. A preemergence treatment of butachlor gave excellent control of barnyardgrass in 1977, gave fair control in 1978, and good to excellent control of aquatic weeds, spreading dayflower, and bearded sprangle-

(*Continued on page 21.*)

Table 12.—Experiment 3 (Stuttgart, 1977): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)	Grain yield (%)	Head rice yield[6] (%)	Germination[6] (%)
				Barnyard-grass	Aquatic weeds[5]	Spreading dayflower				
Thiobencarb	4.5	Preemergence	D	100a	82ab	96a	20ab	7,137ab	59	98
Bifenox	3.4	Preemergence	D	95a	92a	97a	27ab	7,039ab	59	97
Butachlor	3.4	Preemergence	D	97a	85ab	97a	30ab	7,063ab	63	95
Propanil	3.4	Postemergence (2-leaf)	D	73c	20e	40e	0d	6,195ab	60	97
Propanil[7]	4.5	Postemergence (4-leaf)	D	78bc	0f	75cd	0d	6,329ab	62	95
Molinate (G)[7]	3.4	Postemergence (tillering)	F	73c	30de	0f	0d	5,835b	61	97
Thiobencarb followed by propanil.	4.5; 4.5	Preemergence; 1 day before flooding.	D; D	98a	85ab	100a	20bc	6,955ab	63	98
Bifenox followed by propanil.	3.4; 4.5	Preemergence; 1 day before flooding.	D; D	99a	82ab	95a	27abc	7,337ab	60	98
Butachlor followed by propanil.	3.4; 4.5	Preemergence; 1 day before flooding.	D; D	98a	88ab	96a	30ab	7,409a	55	97
Thiobencarb	4.5	Postemergence (2-leaf)	D	93ab	87ab	83bc	20bc	6,854ab	62	98
Bifenox	3.4	Postemergence (2-leaf)	D	33d	75b	83bc	33a	6,296ab	57	96
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	100a	53c	97a	20bc	6,867ab	61	95
Propanil + bifenox (Fl)	3.4+2.2	Postemergence (2-leaf)	D	93ab	55c	82bc	30ab	7,132ab	62	98
Propanil + butachlor	3.4+2.8	Postemergence (2-leaf)	D	90ab	94a	92ab	27abc	7,340ab	58	96
Propanil + butachlor	3.4+3.4	Postemergence (2-leaf)	D	96a	97a	94a	30ab	6,922ab	59	96
Thiobencarb followed by propanil.	4.5; 4.5	Postemergence (2-leaf); 1 day before flooding.	D; D	98a	82ab	94a	20bc	6,453ab	62	97
Bifenox (Fl) followed by propanil.	3.4; 4.5	Postemergence (2-leaf); 1 day before flooding.	D; D	75c	83ab	93a	30ab	6,615ab	62	96
Propanil + molinate followed by molinate (G).	3.4+3.4; 3.4	Postemergence (2-leaf); postemergence (tillering).	D; F	98a	40cd	65d	0d	6,356ab	59	97
Propanil followed by bifenox (G).	4.5; 3.4	Postemergence (4-leaf); 1 day before flooding.	D; D	90ab	98a	96a	17c	7,395a	63	96
Propanil followed by oxyfluorfen (G).	4.5; 0.22	Postemergence (4-leaf); 1 day before flooding.	D; D	78bc	93a	83bc	27abc	6,874ab	61	97
Propanil followed by triclopyr.	4.5; 0.28	Postemergence (4-leaf); 28 days after flooding.	D; D	85abc	20e	67d	0d	6,762ab	61	97
None				0e	24e	0f	0d	4,357c	61	95

[1] 'Starbonnet' rice drill-seeded April 26, emerged May 8. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] Fl, flowable; G, granular. Granular herbicides were broadcast, others were applied in water sprays.

[3] Growth stage given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Ducksalad, redstem, and waterhyssop.

[6] No values are significantly different (at the 5% level).

[7] Standard herbicide treatment.

Table 13.—Experiment 3 (Stuttgart, 1978): influence of herbicide treatment on weed control, crop injury, head rice yield, grain yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)		Injury (%)	Grain yield (kg/ha)	Head rice yield (%)	Germination (%)
				Barnyard-grass	Bearded sprangletop				
Thiobencarb	4.5	Preemergence	D	72c	92a	0b	5,174ab	58b	94abcd
Bifenox (Fl)	3.4	Preemergence	D	13f	23def	0b	1,528d	58b	94abcd
Butachlor	3.4	Preemergence	D	57d	96a	0b	4,993ab	63a	94abcd
Propanil	3.4	Postemergence (2-leaf)	D	27e	7fg	0b	2,509cd	58b	92bcd
Propanil[5]	4.5	Postemergence (4-leaf)	D	86b	30de	0b	6,218a	64a	91cd
Molinate (G)[5]	3.4	Postemergence (tillering)	F	97ab	63c	10ab	5,762a	60ab	94abcd
Thiobencarb followed by molinate (G).	4.5; 3.4	Preemergence 9 days after flooding.	D; F	98a	99a	0b	6,054a	62ab	95abc
Bifenox (Fl) followed by molinate (G).	3.4; 3.4	Preemergence 9 days after flooding.	D; F	95ab	98a	7ab	6,378a	62ab	95abc
Butachlor followed by molinate (G).	3.4; 3.4	Preemergence; 9 days after flooding.	D; F	94ab	98a	0b	5,628a	61ab	96ab
Thiobencarb	4.5	Postemergence (2-leaf)	D	99a	99a	0b	5,826a	60ab	94abcd
Bifenox (Fl)	3.4	Postemergence (2-leaf)	D	60d	30de	10ab	3,738bc	61ab	97a
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf)	D	96ab	99a	0b	6,637a	60ab	95abc
Propanil + bifenox (Fl)	3.4+2.2	Postemergence (2-leaf)	D	60d	37d	0b	4,865ab	59ab	95abc
Propanil + butachlor	3.4+2.8	Postemergence (2-leaf)	D	92ab	99a	10ab	5,697a	59ab	94abcd
Propanil + butachlor	3.4+3.4	Postemergence (2-leaf)	D	96ab	98a	20a	6,691a	63a	95abc
Thiobencarb followed by molinate (G).	4.5; 3.4	Postemergence (2-leaf) 9 days after flooding.	D; F	98a	98a	0b	5,738a	61ab	96ab
Bifenox followed by molinate (G).	3.4; 3.4	Postemergence (2-leaf) 9 days after flooding.	D; F	97ab	83ab	10ab	6,559a	63a	97a
Propanil + molinate followed by molinate (G).	3.4+3.4; 3.4	Postemergence (2-leaf); postemergence (tillering).	D; F	98a	97a	0b	5,771a	58b	95abc
Propanil followed by bifenox (G).	4.5; 3.4	Postemergence (4-leaf); 1 day before flooding.	D; D	93ab	27def	0b	6,350a	63a	95abc
Propanil followed by oxyfluorfen (G).	4.5; 0.22	Postemergence (4-leaf); 1 day before flooding.	D; D	93ab	13efg	0b	6,618a	64a	98a
Propanil followed by triclopyr.	4.5; 0.28	Postemergence (4-leaf); 21 days after flooding.	D; D	93ab	67bc	0b	5,406ab	62ab	96ab
None				0g	0g	0b	1,022d	54b	88de

[1]'Starbonnet' rice drill-seeded April 27, emerged May 9. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Fl, flowable; G, granular. Granular herbicides were broadcast; others were applied in water sprays.

[3]Growth stage given for barnyardgrass.

[4]Floodwater condition at time of treatment: D, drained; F, flooded.

[5]Standard herbicide treatment.

Table 14.—Experiment 3 (Rohwer, 1978): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)				Injury (%)	Grain yield (kg/ha)	Head rice yield (%)	Germination[6] (%)
				Barnyard-grass	Tight-head sprangle-top	Aquatic weeds[5]	Eclipta				
Thiobencarb	4.5	Preemergence	D	88a	88a	90a	78ab	0c	3,376abcd	42abc	96
Bifenox (Fl)	3.4	Preemergence	D	68ab	65ab	90a	65ab	8bc	2,964abcde	44abc	93
Butachlor	4.5	Preemergence	D	88a	88a	90a	82ab	30a	4,890abc	43abc	94
Propanil	3.4	Postemergence (2-leaf)	D	60b	60b	0c	85ab	0c	3,680abcd	42abc	92
Propanil[7]	4.5	Postemergence (4-leaf)	D	0c	0c	0c	0c	0c	2,742abcde	44abc	92
Molinate (G)[7]	3.4	Postemergence (tillering)	F	0c	0c	0c	0c	0c	1,833cde	32d	93
Thiobencarb followed by propanil.	4.5; 4.5	Preemergence; post-emergence (4-leaf).	D; D	90a	88a	90a	88ab	0c	3,972ab	43abc	95
Bifenox (Fl) followed by propanil.	3.4; 4.5	Preemergence; post-emergence (4-leaf).	D; D	90a	90a	90a	82ab	15b	4,142a	47a	94
Butachlor followed by propanil.	3.4; 4.5	Preemergence; post-emergence (4-leaf).	D; D	88a	78ab	78b	68ab	8bc	3,386abcd	44abc	95
Thiobencarb	4.5	Postemergence (2-leaf)	D	22c	22c	90a	22c	0c	2,310abcde	42abc	93
Bifenox (Fl)	3.4	Postemergence (2-leaf)	D	0c	0c	90a	0c	0c	2,045bcde	37bcd	92
Propanil + thiobencarb.	3.4+3.4	Postemergence (2-leaf)	D	88a	82ab	90a	90a	0c	3,623abcd	48a	96
Propanil + bifenox (Fl).	3.4+3.4	Postemergence (2-leaf)	D	82ab	68ab	90a	90a	0c	3,344abcd	47a	94
Propanil + butachlor.	3.4+3.4	Postemergence (2-leaf)	D	75ab	68ab	90a	88ab	5c	3,965ab	46ab	93
Propanil + butachlor.	3.4+4.5	Postemergence (2-leaf)	D	82ab	68ab	90a	88ab	8bc	2,787abcde	44abc	94
Thiobencarb followed by propanil.	4.5; 4.5	Postemergence (2-leaf); postemergence (4-leaf).	D; D	60b	58b	90a	60b	8bc	3,749abcd	44abc	95
Bifenox (Fl) followed by propanil.	3.4; 4.5	Postemergence (2-leaf); postemergence (4-leaf).	D; D	88a	78ab	90a	90a	15b	1,274e	46ab	94
Propanil + molinate followed by molinate (G).	3.4+3.4 3.4	Postemergence (2-leaf); postemergence (tillering).	D; F	85ab	85ab	0c	90a	0c	3,837abc	46ab	92
Propanil followed by bifenox (G).	4.5; 3.4	Postemergence (4-leaf); 1 day before flooding.	D; D	0c	0c	68b	0c	0c	1,089e	35cd	92
Propanil followed by oxyfluorfen (G).	4.5; 0.22	Postemergence (4-leaf); 1 day before flooding.	D; D	0c	0c	58b	0c	0c	1,730de	37bcd	92
Propanil followed by triclopyr.	4.5; 0.28	Postemergence (4-leaf); 21 days after flooding.	D; D	20c	12c	0c	10c	0c	1,698de	40abcd	93
None				0c	0c	0c	0c	0c	2,106bc	42abc	94

top. Rice treated preemergence with butachlor yielded well.

Sequential treatments consisting of thiobencarb, bifenox, or butachlor applied preemergence and followed by standard postemergence applications of propanil or molinate controlled the grass-aquatic-broadleaf weed complexes both years. A postemergence treatment of molinate following these preemergence herbicide treatments improved control of barnyardgrass in 1978, compared with the single preemergence treatments.

Postemergence treatments of thiobencarb alone or tank mixtures of propanil and either thiobencarb or butachlor controlled the grass-aquatic-broadleaf weed complexes in 1977 and 1978. The thiobencarb-propanil mixture controlled aquatic weeds less effectively than thiobencarb alone, apparently because less thiobencarb was present in the mixture.

Bifenox alone applied postemergence controlled aquatic weeds and spreading dayflower but failed to control barnyardgrass or bearded sprangletop. Rice receiving this treatment had reduced grain yields in 1978 because of weed competition. A tank mixture of propanil and bifenox applied postemergence controlled barnyardgrass in 1977 and gave fair control in 1978. It controlled spreading dayflower, and though it gave only partial control of aquatic weeds and bearded sprangletop, failure to control these weeds did not cause a significant reduction in grain yields.

Sequential treatments of thiobencarb or bifenox applied to two-leaf barnyardgrass followed by standard treatments of propanil, applied just before flooding, or molinate, applied just after flooding, controlled the grass-aquatic-broadleaf weed complexes effectively, but thiobencarb controlled barnyardgrass better than bifenox in 1977. In 1978, the molinate treatment applied after flooding may have masked the low activity of bifenox on barnyardgrass. Grain yields were excellent from rice receiving these treatments.

A tank mixture of propanil and molinate, applied postemergence, followed by a granular application of molinate into the floodwater controlled barnyardgrass and bearded sprangletop, and gave fair control of aquatic weeds and spreading dayflower. Rice receiving this treatment yielded well.

A conventional treatment of propanil followed by granular bifenox or oxyfluorfen applied just before flooding controlled barnyardgrass, aquatic weeds, and spreading dayflower but gave poor

[1]'Lebonnet' rice drill-seeded May 25, emerged June 10. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Fl, flowable; G, granular. Granular herbicides were broadcast; others were applied in water sprays.

[3]Growth stage given for barnyardgrass.

[4]Floodwater condition at time of treatment: D, drained; F, flooded.

[5]Ducksalad, redstem, and waterhyssop.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

control of bearded sprangletop. Rice receiving these treatments yielded well.

A sequential treatment of propanil, applied postemergence, followed by triclopyr controlled barnyardgrass and gave partial control of spreading dayflower and bearded sprangletop. Triclopyr failed to control emerged aquatic weeds, which may have reduced grain yields slightly.

Rice quality (head rice yield and seed germination) was not affected by the treatments in 1977, but these components differed significantly among treatments in 1978. However, head rice yields and germination of seed from treated rice were considered excellent in both years. The improvement some treatments showed in 1978 in head rice yields and seed germination over unweeded plots may have resulted from reduced weed competition.

Rohwer.—This experiment was initiated in 1977 but had to be abandoned because heavy rainfall delayed seeding until late spring, and then dry weather reduced rice stands after seeding. In 1978 good stands of rice were obtained and barnyardgrass, tighthead sprangletop, aquatic weeds, and eclipta infested the plots (tables 4, 14).

Standard treatments of propanil or molinate failed to control the grass-aquatic-broadleaf weed complexes, and competition from these weeds reduced grain yield somewhat. Poor performance of the standard propanil treatment was caused by applying the treatments to environmentally stressed weeds. Poor performance of the molinate treatment was caused by failure to maintain a continuous flood after application. Propanil applied at barnyardgrass' two-leaf stage gave fair to good control of barnyardgrass, tighthead sprangletop, and eclipta but failed to control aquatic weeds. Grain yields from all treatments were low because vegetative growth was stressed by intermittent flooding and draining. No treatment injured rice more than slightly.

Preemergence applications of thiobencarb, bifenox, or butachlor gave fair to good control of all weeds. Standard propanil treatments following these preemergence treatments improved control of the weed complexes slightly over preemergence treatments alone. The preemergence herbicide component in the sequential treatments improved weed control, compared with standard treatments of propanil or molinate.

Postemergence treatments of thiobencarb, and bifenox alone (applied to barnyardgrass' two-leaf stage) controlled aquatic weeds but failed to control grass weeds or eclipta, and competition from these weeds reduced grain yields.

Tank mixtures of propanil with thiobencarb, bifenox, or butachlor applied postemergence gave fair to good control of the grass-aquatic-broadleaf weed complexes, and they controlled weeds better than standard treatments of propanil or molinate.

Treatments of thiobencarb or bifenox applied to two-leaf barnyardgrass followed by a standard treatment of propanil gave fair to good control of all weeds, but grain yields from plots treated with bifenox were extremely low for some unknown reason.

A postemergence treatment of a propanil-molinate tank mixture followed by a standard treatment of granular molinate controlled barnyardgrass, tighthead sprangletop, and eclipta, but failed to control aquatic weeds. Rice receiving this treatment yielded well.

Standard treatments of propanil followed by postemergence treatments of either granular bifenox or oxyfluorfen or sprays of triclopyr failed to control most weeds. Granular applications of bifenox and oxyfluorfen did give fair control of aquatic weeds, but triclopyr applied to emerged aquatic weeds gave no control. Grain yields from plots receiving these treatments were low.

Head rice yields from all the plots were low (below 50%), but they did not follow a pattern associated with treatments or level of weed control. Low head rice yields were probably caused by harvesting grain with low moisture (less than 18%). The combine breaks dry grains and reduces head rice yields (Johnston and Miller 1973). Seed quality was excellent, and more than 90% of the seed harvested from all plots germinated.

Experiment 4

Barnyardgrass and aquatic weeds infested the plots all 3 years; bearded sprangletop also infested the plots in 1976 and 1978 (tables 4, 15-17).

Early injury ratings taken 6 to 14 days after rice emergence indicated that none of the treatments injured rice excessively, but some treatments injured rice more than others. Thiobencarb, applied preemergence or early postemergence, alone or in combination with propanil, injured rice moderately. Higher rates of thiobencarb, applied postemergence, alone or in mixtures with propanil, injured rice

(*Continued on page 26.*)

Table 15.—Experiment 4 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
			Barnyard-grass[4]	Bearded sprangle-top[4]	Aquatic weeds[5]	6 days after emergence	67 days after emergence			
Propanil[7]	4.5	Postemergence (4-leaf), 11 days after emergence.	100a	67b	0e	0c	0	7,421bc	67	97
Thiobencarb	4.5	Preemergence, 7 days before emergence.	100a	100a	83c	33a	0	8,652a	66	98
Thiobencarb	9.0	Preemergence, 7 days before emergence.	100a	100a	100a	40a	0	7,941abc	67	99
Propanil	0.84	Postemergence (2-leaf), 1 day after emergence.	89ab	70b	0e	0c	0	7,978abc	68	97
Propanil	3.4	Postemergence (2-leaf), 1 day after emergence.	87b	77ab	0e	2c	0	7,262d	67	96
Thiobencarb	3.4	Postemergence (2-leaf), 1 day after emergence.	100a	98a	82c	13b	0	7,697abcd	68	98
Thiobencarb	4.5	Postemergence (2-leaf), 1 day after emergence.	100a	100a	80cd	17b	0	8,243abc	68	98
Thiobencarb	9.0	Postemergence (2-leaf), 1 day after emergence.	100a	100a	100a	27b	0	8,329abc	67	97
Propanil + thiobencarb	0.84+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	100a	91b	13b	0	7,707abc	67	98
Propanil + thiobencarb	1.7+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	100a	78cd	17b	0	8,473ab	68	98
Propanil + thiobencarb	2.2+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	100a	75d	20b	0	8,316abc	67	97
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	100a	77cd	13b	0	8,393abc	67	98
Propanil + thiobencarb	6.7+6.7	Postemergence (2-leaf), 1 day after emergence.	100a	98a	98a	33a	0	8,230abc	66	98
Propanil + molinate	3.4+2.2	Postemergence (4-leaf), 11 days after emergence.	87b	60b	0e	0c	0	8,067abc	68	98
None			0c	0c	0e	0c	0	7,421bcd	68	97

[1]'Starbonnet' rice drill-seeded April 29, emerged May 14. All plots were flush-irrigated to keep soil moist and were flooded 17 days after emergence. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]All herbicides were applied as sprays to drained plots.

[3]Leaf number given for barnyardgrass.

[4]Barnyardgrass and bearded sprangletop were evaluated 67 days after emergence.

[5]Aquatic weeds (ducksalad, false pimpernel, redstem, and waterhyssop) were evaluated 36 days after emergence.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

Table 16.—Experiment 4 (Stuttgart, 1977): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)		Injury (%)		Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
			Barnyard-grass[4]	Aquatic weeds[5]	9 days after emergence	53 days after emergence			
Propanil[7]	4.5	Postemergence (4-leaf), 8 days after emergence.	82b	0b	0d	0	6,666cd	63	96
Thiobencarb	4.5	Preemergence 5 days before emergence.	98a	92a	22b	0	7,159ab	61	95
Thiobencarb	9.0	Preemergence 5 days before emergence.	100a	93a	37a	0	7,316a	65	96
Propanil	0.84	Postemergence (2-leaf), 1 day after emergence.	37c	0b	2d	0	5,722e	67	95
Propanil	3.4	Postemergence (2-leaf), 1 day after emergence.	90a	0b	10c	0	6,477d	68	96
Thiobencarb	3.4	Postemergence (2-leaf), 1 day after emergence.	88ab	93a	18c	0	7,010abc	68	97
Thiobencarb	4.5	Postemergence (2-leaf), 1 day after emergence.	98a	93a	20bc	0	7,001abc	67	97
Thiobencarb	9.0	Postemergence (2-leaf), 1 day after emergence.	100a	97a	37a	0	6,746bcd	64	95
Propanil + thiobencarb	0.84+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	92a	23ab	0	7,154abc	67	97
Propanil + thiobencarb	1.7+3.4	Postemergence (2-leaf), 1 day after emergence.	97a	92a	27ab	0	7,122abc	64	95
Propanil + thiobencarb	2.2+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	90a	30ab	0	6,918abc	62	97
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf), 1 day after emergence.	100a	93a	37a	0	7,115abc	62	97
Propanil + thiobencarb	6.7+6.7	Postemergence (2-leaf), 1 day after emergence.	98a	93a	40ab	0	7,030abc	65	96
Propanil + molinate	3.4+2.2	Postemergence (2-leaf), 8 days after emergence.	80b	0b	0d	0	6,393d	68	96
None			0d	0b	0d	0	5,961e	65	96

[1]'Starbonnet' rice drill-seeded April 26, emerged May 8. All plots were flush-irrigated to keep soil moist and were flooded 16 days after emergence. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]All herbicides were applied as sprays to drained plots.

[3]Leaf number given for barnyardgrass.

[4]Barnyardgrass was evaluated 60 days after emergence.

[5]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 53 days after emergence.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

Table 17.—Experiment 4 (Stuttgart, 1978): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield (%)	Germination (%)
			Barnyard-grass[4]	Bearded sprangle-top[4]	Aquatic weeds[5]	14 days after emergence	55 days after emergence			
Propanil[6]	4.5	Postemergence (4-leaf), 13 days after emergence.	96ab	43b	0c	0e	0b	6,998ab	59abc	97a
Thiobencarb	4.5	Preemergence, 4 days before emergence.	88ab	98a	47b	30b	0b	6,362ab	60abc	97a
Thiobencarb	9.0	Preemergence, 4 days before emergence.	92ab	97a	53b	43a	7ab	6,951ab	57bcde	96a
Propanil	0.84	Postemergence (2-leaf), 6 days after emergence.	53b	10cd	0c	0e	0b	4,178c	60abc	96a
Propanil	3.4	Postemergence (2-leaf), 6 days after emergence.	87ab	17c	0c	0e	0b	5,766b	58bcd	97a
Thiobencarb	3.4	Postemergence (2-leaf), 6 days after emergence.	97a	94a	87a	23cd	0b	6,582ab	54de	93b
Thiobencarb	4.5	Postemergence (2-leaf), 6 days after emergence.	98a	98a	93a	27bc	10a	7,161a	58bcd	96a
Thiobencarb	9.0	Postemergence (2-leaf), 6 days after emergence.	97a	97a	93a	37a	7ab	6,864ab	61ab	96a
Propanil + thiobencarb	0.84+3.4	Postemergence (2-leaf), 6 days after emergence.	98a	98a	93a	20d	0b	7,041ab	56cde	97a
Propanil + thiobencarb	1.7+3.4	Postemergence (2-leaf), 6 days after emergence.	98a	98a	85a	27bc	0b	7,268a	59abc	96a
Propanil + thiobencarb	2.2+3.4	Postemergence (2-leaf), 6 days after emergence.	98a	98a	93a	23cd	0b	7,123ab	58bcd	96a
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf), 6 days after emergence.	98a	98a	92a	23cd	0b	5,770b	58bcd	95ab
Propanil + thiobencarb	6.7+6.7	Postemergence (2-leaf), 6 days after emergence.	98a	98a	88a	40a	0b	5,638b	60abc	96a
Propanil + molinate	3.4+2.2	Postemergence (4-leaf), 13 days after emergence.	97a	97a	0c	0e	0b	6,946ab	62a	97a
None			0c	0d	0c	0e	0b	2,262d	53e	93b

[1]'Starbonnet' rice drill-seeded April 27, emerged May 9. All plots were flush-irrigated to keep soil moist and were flooded 21 days after emergence. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]All herbicides were applied as sprays to drained plots.

[3]Leaf stage given for barnyardgrass.

[4]Barnyardgrass and bearded sprangletop were evaluated 55 days after emergence.

[5]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 57 days after emergence.

[6]Standard herbicide treatment.

more than lower rates. However, by midseason (50 to 70 days after seeding) the rice had recovered from the early injury.

A standard treatment of propanil controlled more than 80% of the barnyardgrass in all years, but it failed to control the aquatic weeds and only partially controlled bearded sprangletop. Propanil applied at 3.4 kg/ha at barnyardgrass' two-leaf stage, controlled barnyardgrass all years, failed to control aquatic weeds all years, gave good control of bearded sprangletop in 1976, and failed to control bearded sprangletop weed in 1978.

Preemergence treatments of thiobencarb controlled barnyardgrass and bearded sprangletop in all years and controlled the aquatic weed complex in 1976 and 1977.

Postemergence treatments of thiobencarb alone controlled barnyardgrass, bearded sprangletop, and aquatic weeds in all years. A rate of 3.4 kg/ha controlled more than 80% of the grass-aquatic weed complex and was usually as effective as higher rates.

Tank mixtures of propanil and thiobencarb applied early postemergence controlled emerged grass weeds and those that emerged after treatment and controlled aquatic weeds that emerged after flooding. This tank mixture controlled the weed complex better than the standard propanil treatment, but not any better than postemergence treatments of thiobencarb alone.

In all years, propanil-molinate tank mixtures controlled four-leaf barnyardgrass satisfactorily but failed to control aquatic weeds. This mixture controlled bearded sprangletop in 1978 and gave fair control in 1976.

Because infestations of the weed complexes varied among years (table 2), grain yields from untreated rice were affected more by weed competition in some years than in others. In 1976, weed infestations reduced grain yields of the unweeded plots slightly. In 1977, a moderate infestation of barnyardgrass (22 panicles/m^2) and a heavy infestation of aquatic weeds (800 plants/m^2) reduced the yields of the unweeded plots moderately. In 1978, infestations of barnyardgrass (97 panicles/m^2) and bearded sprangletop (86 panicles/m^2) reduced yields severely. Therefore, grain yield reflected the species and level of weeds present in the plots. Rice in which the barnyardgrass-bearded sprangletop-aquatic weed complex was controlled had (with few exceptions) high grain yields, and rice in which the weed complex was not controlled, usually had low grain yields.

Rice quality (measured by head rice yields and seed germination) was excellent in all years. Germination of seed harvested from treated rice was not significantly different from unweeded rice in any year. Head rice yields were not significantly different among treatments in 1976 and 1977, but in 1978, head rice yields from treated rice frequently were better than those from untreated rice. Heavy weed competition probably reduced head rice yields from the unweeded plots that year.

Experiment 5

Barnyardgrass, bearded sprangletop, and aquatic weeds infested the plots in all 3 years (tables 2, 18-20).

Five treatments applied in 1976 were not repeated in 1977 and 1978. These were a preemergence treatment of oxadiazon at 0.84 kg/ha; a preemergence treatment of oxadiazon at 1.1 kg/ha followed by a postemergence application of propanil; postemergence applications of tank mixtures of propanil and oxadiazon at rates of 3.4+0.84 and 3.4+1.1 kg/ha; and a postemergence treatment of propanil followed by bentazon at 0.56 kg/ha. All other treatments were repeated each year.

Early injury ratings taken 14 to 38 days after rice emergence indicated that some treatments injured rice more than others. Injury levels varied among years. Treatments that caused moderate injury to rice in at least 1 year included preemergence applications of oxyfluorfen or oxadiazon, applied alone or followed by postemergence applications of propanil; preemergence applications of oxyfluorfen followed by thiobencarb or molinate; postemergence applications of propanil and oxadiazon or propanil and butachlor; and postemergence applications of propanil followed by granular oxyfluorfen. However, in all years rice recovered from this early injury by midseason (45 to 65 days after emergence). In 1976, rice treated with a granular application of oxyfluorfen followed by granular molinate was injured severely, and this injury persisted through midseason, but the rice recovered by late season (100 to 120 days after emergence) and grain yields were not reduced. The injury was usually manifested as slight crop-stand reductions and slight to moderate chlorosis of rice plants.

Standard treatments of propanil gave fair to good control of barnyardgrass, partial control of bearded sprangletop, and no control of aquatic

(*Continued on page 32.*)

Table 18.—Experiment 5 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
				Barnyardgrass[5]	Bearded sprangletop[5]	Aquatic weeds[6]	38 days after emergence	62 days after emergence			
Oxyfluorfen	0.28	Preemergence, 11 days before emergence.	D	82bc	89ab	43d	27c	0c	7,478a	66	97
Oxadiazon	0.84	Preemergence, 11 days before emergence.	D	95a	100a	98a	27c	0c	8,456a	67	99
Oxadiazon	1.1	Preemergence, 11 days before emergence.	D	98a	99a	96ab	20d	0c	8,343a	67	98
Propanil[8]	4.5	Postemergence (4-leaf), 7 days after emergence.	D	73d	43c	0e	0h	0c	7,591a	69	97
Molinate (G)[8]	3.4	Postemergence (tillering), 24 days after emergence.	F	99a	98a	13e	27c	0c	7,942a	65	97
Oxyfluorfen followed by propanil	0.28; 4.5	Preemergence, 11 days before emergence; postemergence (4-leaf), 7 days after emergence.	D; D	99a	100a	70c	13ef	0c	8,431a	69	99
Oxyfluorfen followed by thiobencarb.	0.28; 4.5	Preemergence, 11 days before emergence; postemergence (2-leaf), 1 day after emergence.	D; D	100a	100a	100a	27c	0c	8,271a	66	97
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence, 11 days before emergence; postemergence (4-leaf), 7 days after emergence.	D; D	100a	100a	99a	20d	0c	8,417a	69	98
Oxadiazon followed by propanil.	1.1; 3.4	Preemergence, 11 days before emergence; postemergence (4-leaf), 7 days after emergence.	D; D	100a	100a	95ab	10fg	0c	8,208a	69	96
Oxyfluorfen followed by molinate (G).	0.28; 3.4	Preemergence, 11 days before emergence; postemergence (tillering), 24 days after emergence.	D; F	100a	92a	82bc	10fg	0c	8,468a	66	98
Thiobencarb	4.5	Postemergence (2-leaf), 1 day after emergence.	D	100a	100a	43d	20d	0c	8,242a	68	97
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf), 1 day after emergence.	D	100a	97a	97ab	17de	0c	8,203a	67	97
Propanil + oxadiazon	3.4+0.84	Postemergence (2-leaf) 1 day after emergence.	D	100a	100a	99a	13ef	0c	8,329a	67	97
Propanil + oxadiazon	3.4+1.1	Postemergence (2-leaf), 1 day after emergence.	D	100a	97a	99a	27c	10b	7,860a	67	99
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf), 1 day after emergence.	D	99a	100a	47d	13ef	0c	8,383a	66	97

See footnotes at end of table.

Table 18.—Experiment 5 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]—*Continued*

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
				Barnyardgrass[5]	Bearded sprangletop[5]	Aquatic weeds[6]	38 days after emergence	62 days after emergence			
Propanil + butachlor	3.4+3.4	Postemergence (2-leaf), 1 day after emergence.	D	100a	100a	87ab	13ef	0c	8,417a	66	99
Propanil followed by bentazon.	3.4; 0.56	Postemergence (4-leaf), 7 days after emergence; 37 days after emergence.	D; D	85b	47c	0e (70)	7g	0c	8,014a	69	99
Propanil followed by bentazon.	4.5; 0.84	Postemergence (4-leaf), 7 days after emergence; 37 days after emergence.	D; D	75cd	72abc	0e (80)	7g	0c	8,175a	68	99
Propanil followed by oxyfluorfen.	4.5; 0.22	Postemergence (4-leaf), 7 days after emergence; 20 days after emergence.	D; D	95a	62bc	100a	40b	10b	7,978a	68	99
Molinate (G) followed by bentazon.	3.4; 0.84	Postemergence (tillering), 24 days after emergence; 37 days after emergence.	F; D	100a	50c	0e (80)	17de	0c	8,036a	68	97
Oxyfluorfen (G) followed by molinate (G).	0.22; 3.4	Postemergence, 20 days after emergence; postemergence (tillering), 24 days after emergence.	D; F	100a	100a	100a	73a	67a	7,673a	67	97
None				0e	0d	0e	0h	0c	5,535b	66	100

[1] 'Starbonnet' rice drill-seeded April 27, emerged May 18. All plots were flush-irrigated to keep soil moist and were flooded 21 days after emergence. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] Granular herbicides (G) were broadcast; other herbicides were applied in water sprays.

[3] Growth stage given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Barnyardgrass and bearded sprangletop were evaluated 62 days after emergence.

[6] Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 38 days after emergence; values in parentheses were taken 2 weeks after the bentazon application.

[7] No values are significantly different (at the 5% level).

[8] Standard herbicide treatment.

Table 19.—Experiment 5 (Stuttgart, 1977): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
				Barnyardgrass[5]	Bearded sprangletop[5]	Aquatic weeds[6]	17 days after emergence	46 days after emergence			
Oxyfluorfen	0.28	Preemergence, 4 days before emergence.	D	87bc	94ab	93abc	37bc	0	5,359ab	64	97
Oxadiazon	1.1	Preemergence, 4 days before emergence.	D	95ab	100a	99ab	63a	0	6,129ab	62	96
Propanil[8]	4.5	Postemergence (4-leaf), 10 days after emergence.	D	77d	68d	0e	13d	0	5,575ab	62	95
Molinate (G)[8]	3.4	Postemergence (tillering), 24 days after emergence.	F	95ab	80c	0e	0e	0	5,666ab	63	92
Oxyfluorfen followed by propanil.	0.28; 4.5	Preemergence, 4 days before emergence; postemergence (4-leaf),10 days after emergence.	D; D	96a	98a	99ab	40b	0	6,113ab	63	97
Oxyfluorfen followed by thiobencarb.	0.28; 4.5	Preemergence, 4 days before emergence; postemergence (2-leaf), 2 days after emergence.	D; D	99a	98a	99ab	37bc	0	5,153b	62	96
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence, 4 days before emergence; postemergence (4-leaf), 10 days after emergence.	D; D	99a	99a	100a	57a	0	6,584a	62	96
Oxyfluorfen followed by molinate (G).	0.28; 3.4	Preemergence, 4 days before emergence; postemergence (tillering), 24 days after emergence.	D; F	99a	98a	99ab	37bc	0	6,227ab	65	96
Thiobencarb	4.5	Postemergence (2-leaf), 2 days after emergence.	D	99a	100a	92bc	25c	0	5,678ab	62	95
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf), 2 days after emergence.	D	93ab	93ab	99ab	23c	0	5,282ab	64	93
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf), 2 days after emergence.	D	98a	100a	82d	30c		5,962ab	64	93
Propanil + butachlor	3.4+3.4	Postemergence (2-leaf), 2 days after emergence.	D	96a	100a	100a	30c	0	6,293ab	64	95
Propanil followed by bentazon.	4.5; 0.84	Postemergence (4-leaf), 10 days after emergence; 38 days after emergence.	D; D	78d	80c	90c	13d	0	6,312ab	65	95

See footnotes at end of table.

Table 19.—Experiment 5 (Stuttgart, 1977): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]—*Continued*

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
				Barnyardgrass[5]	Bearded sprangletop[5]	Aquatic weeds[6]	17 days after emergence	46 days after emergence			
Propanil followed by oxyfluorfen (G).	4.5; 0.22	Postemergence (4-leaf), 10 days after emergence; 19 days after emergence.	D; D	83cd	63d	99ab	13d	0	6,453b	63	93
Molinate (G) followed by bentazon.	3.4; 0.84	Postemergence (tillering), 24 days after emergence; 38 days after emergence.	F; D	97a	82c	94abc	0e	0	6,270ab	63	93
Oxyfluorfen (G) followed by molinate (G).	0.22; 3.4	Postemergence, 19 days after emergence; postemergence (tillering), 24 days after emergence.	D; F	99a	87bc	99ab	0e	0	5,991ab	64	95
None				0e	0e	0e	0e	0	4,397c	62	94

[1] 'Starbonnet' rice drill-seeded May 4, emerged May 14. All plots were flush-irrigated to keep soil moist and were flooded 20 days after emergence. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).
[2] Granular herbicides (G) were broadcast; other herbicides were applied in water sprays.
[3] Growth stage given for barnyardgrass.
[4] Floodwater condition at time of treatment: D, drained; F, flooded.
[5] Barnyardgrass and bearded sprangletop were evaluated 63 days after emergence.
[6] Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 46 days after emergence.
[7] No values are significantly different (at the 5% level).
[8] Standard herbicide treatment.

Table 20.—Experiment 5 (Stuttgart, 1978): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of dry-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Water management[4]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield (%)	Germination[7] (%)
				Barnyardgrass[5]	Bearded sprangletop[5]	Aquatic weeds[6]	14 days after emergence	55 days after emergence			
Oxyfluorfen	0.28	Preemergence, 4 days before emergence.	D	43d	53c	17de	30ab	0b	5,687bc	55f	96
Oxadiazon	1.1	Preemergence, 4 days before emergence.	D	83c	95a	53b	27b	10ab	6,179bc	61abc	96
Propanil[8]	4.5	Postemergence (4-leaf), 13 days after emergence.	D	94ab	67bc	0e	0e	0b	6,658bc	58de	96

Molinate (G)[8]	3.4	Postemergence (tillering), 22 days after emergence.	F	98a	83ab	0e	0e	0b	7,141bc	60bcd	96
Oxyfluorfen followed by propanil.	0.28; 4.5	Preemergence, 4 days before emergence; postemergence (4-leaf),13 days after emergence.	D; D	97ab	91a	30cd	30ab	0b	7,265a	58de	96
Oxyfluorfen followed by thiobencarb.	0.28; 4.5	Preemergence, 4 days before emergence; postemergence (2-leaf), 6 days after emergence.	D; D	95ab	94a	95a	30ab	10ab	5,300bc	61abc	96
Oxadiazon followed by propanil.	0.84; 3.4	Preemergence, 4 days before emergence; postemergence (4-leaf), 13 days after emergence.	D; D	95ab	94a	40bc	30ab	0b	7,409a	57ef	98
Oxyfluorfen followed by molinate (G).	0.28; 3.4	Preemergence, 4 days before emergence; postemergence (tillering), 22 days after emergence.	D; F	98a	89a	53b	30ab	23a	7,309a	61abc	95
Thiobencarb	4.5	Postemergence (2-leaf), 6 days after emergence.	D	97ab	98a	92a	13d	0b	6,981bc	57ef	97
Propanil + oxadiazon	2.2+0.84	Postemergence (2-leaf), 6 days after emergence.	D	98a	85ab	92a	33a	0b	7,603bc	59cde	98
Propanil + thiobencarb	3.4+3.4	Postemergence (2-leaf), 6 days after emergence.	D	98a	98a	83a	20c	0b	6,928bc	59cde	96
Propanil + butachlor	3.4+3.4	Postemergence (2-leaf), 6 days after emergence.	D	98a	9	92a	33a	13ab	6,873bc	60bcd	96
Propanil followed by bentazon.	4.5; 0.84	Postemergence (4-leaf), 13 days after emergence; 37 days after emergence.	D; D	98a	0d	92a	0e	10ab	6,742bc	63a	97
Propanil followed by oxyfluorfen (G).	4.5; 0.22	Postemergence (4-leaf), 13 days after emergence; 21 days after emergence.	D; D	98a	68bc	95a	0e	0b	7,095bc	60bcd	97
Molinate (G) followed by bentazon.	3.4; 0.84	Postemergence (tillering), 22 days after emergence; 37 days after emergence.	F; D	98a	80ab	95a	0e	10ab	6,383bc	61abc	95
Oxyfluorfen (G) followed by molinate (G).	0.22; 3.4	Postemergence, 21 days after emergence; postemergence (tillering), 22 days after emergence.	D; F	98a	87a	95a	0e	0b	7,162bc	62ab	96
None				0e	0d	0e	0e	0b	3,356d	59cde	95

[1] 'Starbonnet' rice drill-seeded April 26, emerged May 9. All plots were flush-irrigated to keep soil moist and were flooded 22 days after emergence. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2] Granular herbicides (G) were broadcast; other herbicides were applied in water sprays.

[3] Growth stage given for barnyardgrass.

[4] Floodwater condition at time of treatment: D, drained; F, flooded.

[5] Barnyardgrass and bearded sprangletop were evaluated 55 days after emergence.

[6] Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 58 days after emergence.

[7] No values are significantly different (at the 5% level).

[8] Standard herbicide treatment.

weeds. Standard treatments of molinate gave good control of barnyardgrass and bearded sprangletop but little, if any, control of aquatic weeds.

Oxyfluorfen applied preemergence gave poor to excellent control of barnyardgrass, bearded sprangletop, and aquatic weeds. It controlled barnyardgrass and bearded sprangletop in 2 of 3 years, and it controlled aquatic weeds in 1 of 3 years. Propanil, molinate, or thiobencarb applied postemergence following a preemergence application of oxyfluorfen frequently improved control of the grass-aquatic weed complex over oxyfluorfen alone, applied preemergence. Granular oxyfluorfen applied after a standard propanil treatment or before a standard molinate treatment controlled the grass-aquatic weed complex better than standard treatments of propanil or molinate or a single preemergence application of oxyfluorfen.

Oxadiazon applied preemergence controlled barnyardgrass and bearded sprangletop in all years and controlled aquatic weeds in 2 of 3 years. Following the oxadiazon with a postemergence application of propanil did not improve control of the grass-aquatic weed complex over oxadiazon alone. Postemergence applications of a propanil-oxadiazon tank mixture controlled barnyardgrass, bearded sprangletop, and aquatic weeds in all years.

Thiobencarb applied postemergence controlled barnyardgrass and bearded sprangletop in all years and controlled aquatic weeds in 2 of 3 years. Postemergence application of tank mixtures of thiobencarb and propanil improved weed control little, if any, over postemergence application of thiobencarb alone.

Postemergence applications of propanil and butachlor controlled barnyardgrass, bearded sprangletop, and aquatic weeds in all years.

Bentazon applied at 0.84 kg/ha after standard treatments of either propanil or molinate and after germination of aquatic weeds controlled the aquatic weed complex in all years. Bentazon was always applied to drained plots to expose aquatic weeds to the spray. Propanil or molinate used in sequence with bentazon did not always control barnyardgrass and sprangletop, but the bentazon controlled the aquatic weeds that germinated after these standard treatments.

All herbicide treatments increased grain yields over those from unweeded plots. In no year did grain yields of rice from any treatment differ greatly from those of rice treated with standard applications of propanil or molinate.

Head rice yields and seed germination were excellent for all treatments in all years. Germination levels did not differ significantly among treatments in any year. Head rice yields differed significantly among treatments in 1978, but the yields were satisfactory (55% or more) from all treated plots.

Water-Seeded Rice

Experiment 6

Early injury ratings taken 27 to 33 days after seeding indicated that many of the herbicide treatments injured rice moderately (tables 21-23). This injury was usually manifested as slight crop-stand reduction and slight to moderate inhibition of plant growth. Injury ratings made at midseason (53 to 70 days after seeding) indicated that in most cases the injury was temporary, ranging from slight to moderate inhibition of plant growth. A standard postemergence treatment of 2,4,5-T injured rice more than a standard postemergence treatment of propanil, and injury to rice treated with 2,4,5-T persisted through midseason. Other treatments that caused moderate rice injury through midseason were thiobencarb applied 10 days after seeding at 3.4 kg/ha and sodium azide applied 15 days after seeding at 3.4 kg/ha.

Standard postemergence treatments of propanil or 2,4,5-T failed to control the aquatic weed complex (predominantly ducksalad, but also redstem, spikerush, and waterhyssop) in any year. The growth stage of aquatic weeds and rice at the time of treatment are given in table 24.

Time and rate of application of thiobencarb affected control of the aquatic weed complex. In 2 of 3 years all rates applied 10 days after seeding controlled more than 70% of the one-leaf aquatic weeds. In 1974, however, rates of 2.2 and 3.4 kg/ha gave good control of aquatics, but 1.1 kg/ha gave only fair control. When thiobencarb was applied 15 days after seeding, rates of 2.2 and 3.4 kg/ha controlled two-leaf aquatic weeds in all years. A rate of 1.1 kg/ha controlled them in 2 of 3 years (in 1973 this rate gave only fair control). When thiobencarb was applied 20 days after seeding, a rate of 3.4 kg/ha gave good to excellent control of four-leaf aquatic weeds in all years; 2.2 kg/ha gave good to excellent control in 2 of 3 years; and 1.1 kg/ha gave excellent control in 1 of 3 years and fair control in the other 2 years.

(*Continued on page 36.*)

Table 21.—Experiment 6 (Stuttgart, 1973): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury[5] (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
Thiobencarb	1.1	Postemergence, 10 days after seeding	80ef	10bcd	8,596b	64	96
Thiobencarb	2.2	Postemergence, 10 days after seeding	85cd	7cd	9,078a	64	96
Thiobencarb	3.4	Postemergence, 10 days after seeding	90ab	7cd	8,342b	65	98
Propanil[7]	3.4	Postemergence, 15 days after seeding	10l	0d	7,946c	65	97
2,4,5-T[7]	0.8	Postemergence, 15 days after seeding	30k	43a	8,314bc	65	96
Potassium azide (G)	3.4	Postemergence, 15 days after seeding	85cd	7cd	8,903a	64	96
Sodium azide (G)	3.4	Postemergence, 15 days after seeding	77fg	17bc	8,142bc	65	99
Thiobencarb	1.1	Postemergence, 15 days after seeding	55i	0d	8,299bc	64	97
Thiobencarb	2.2	Postemergence, 15 days after seeding	75g	13bc	8,494b	64	97
Thiobencarb	3.4	Postemergence, 15 days after seeding	78efg	27b	8,319bc	64	97
Propanil + thiobencarb	3.4+1.1	Postemergence, 15 days after seeding	70h	27b	7,989c	65	97
Propanil + thiobencarb	3.4+2.2	Postemergence, 15 days after seeding	87bc	7cd	8,362bc	64	97
Thiobencarb	1.1	Postemergence, 20 days after seeding	47j	0d	8,234bc	65	96
Thiobencarb	2.2	Postemergence, 20 days after seeding	78efg	0d	8,393bc	65	98
Thiobencarb	3.4	Postemergence, 20 days after seeding	92a	0d	8,661a	65	97
Propanil + thiobencarb	3.4+1.1	Postemergence, 20 days after seeding	83de	27b	8,514b	65	97
Propanil + thiobencarb	3.4+2.2	Postemergence, 20 days after seeding	78efg	13b	8,757a	65	97
None			0m	0d	8,186bc	65	97

[1]'Starbonnet' rice seeded into floodwater May 4, emerged May 14. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast into flooded plots; other herbicides were applied in water sprays to drained plots. Plots were drained 1-2 days before applying sprays and reflooded 1-2 days after.

[3]See table 24 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 50 days after seeding.

[5]Injury was evaluated 27 days after seeding; no midseason evaluation was made.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

Table 22.—Experiment 6 (Stuttgart, 1974): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury (%)		Grain yield (kg/ha)	Head rice yield (%)	Germination (%)
				32 days after seeding	53 days after seeding			
Thiobencarb	1.1	Postemergence, 10 days after seeding.	47c	30ab	30ab	5,928abc	56a	94a
Thiobencarb	2.2	Postemergence, 10 days after seeding.	75bc	43a	27bc	5,631cd	57a	93a
Thiobencarb	3.4	Postemergence, 10 day after seeding.	88b	43a	33ab	5,845bcd	57a	94a
Propanil[5]	3.4	Postemergence, 15 days after seeding.	30d	3.3ab	0d	5,366d	56a	92a
2,4,5-T[5]	0.8	Postemergence, 15 days after seeding.	37d	47a	40a	5,580bcd	57a	91ab
Potassium azide (G)	3.4	Postemergence, 15 days after seeding.	80ab	33ab	20bc	5,886abc	54b	94a
Sodium azide (G)	3.4	Postemergence, 15 days after seeding.	85ab	47a	30ab	5,510cd	55ab	92a
Thiobencarb	1.1	Postemergence, 15 days after seeding.	82ab	33ab	0d	5,915abc	57a	92a
Thiobencarb	2.2	Postemergence, 15 days after seeding.	92a	37ab	0d	6,027bc	58a	91ab
Thiobencarb	3.4	Postemergence, 15 days after seeding.	94a	43a	10cd	6,113ab	57a	93a
Propanil + thiobencarb	3.4+1.1	Postemergence, 15 days after seeding.	85ab	43a	17cd	5,786cd	56a	90ab
Propanil + thiobencarb	3.4+2.2	Postemergence, 15 days after seeding.	92a	47a	0d	6,375a	54b	93a
Thiobencarb	1.1	Postemergence, 20 days after seeding.	33d	20b	0d	5,705cd	56a	91ab
Thiobencarb	2.2	Postemergence, 20 days after seeding.	55c	27b	0d	6,079ab	57a	86b
Thiobencarb	3.4	Postemergence, 20 days after seeding.	83ab	23b	0d	6,288a	57a	92a
Propanil + thiobencarb	3.4+1.1	Postemergence, 20 days after seeding.	70bc	33ab	0d	5,855abc	57a	94a
Propanil + thiobencarb	3.4+2.2	Postemergence, 20 days after seeding.	85ab	33ab	0d	6,156ab	56a	94a
None			0e	0c	0d	5,880abc	57a	92a

[1]'Starbonnet' rice seeded into floodwater April 23, emerged May 3. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast into flooded plots; other herbicides were applied in water sprays to drained plots. Plots were drained 1-2 days before applying sprays and reflooded 1-2 days after.

[3]See table 24 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 70 days after seeding.

[5]Standard herbicide treatment.

Table 23.—Experiment 6 (Stuttgart, 1975): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury (%)		Grain yield (kg/ha)	Head rice yield (%)	Germination (%)
				33 days after seeding	70 days after seeding			
Thiobencarb	1.1	Postemergence, 10 days after seeding.	85a	33cd	10b	7,208ab	56de	94b
Thiobencarb	2.2	Postemergence, 10 days after seeding.	88a	33cd	10b	6,972cdefg	60a	95b
Thiobencarb	3.4	Postemergence, 10 days after seeding.	95a	38abc	10b	7,082abcd	56de	95b
Propanil[5]	3.4	Postemergence, 15 days after seeding.	47c	0g	0b	6,983abcde	59ab	94b
2,4,5-T[5]	0.8	Postemergence, 15 days after seeding.	57b	43a	37a	6,740defg	56de	97a
Thiobencarb	1.1	Postemergence, 15 days after seeding.	93a	28de	0b	6,840cdefg	55e	95b
Thiobencarb	2.2	Postemergence, 15 days after seeding.	90a	28de	0b	6,718efg	56de	93b
Thiobencarb	3.4	Postemergence, 15 days after seeding.	95a	43a	0b	6,645fg	58bc	94b
Propanil + thiobencarb	3.4+1.1	Postemergence, 15 days after seeding.	95a	23ef	7b	6,558g	59ab	97a
Propanil + thiobencarb	3.4+2.2	Postemergence, 15 days after seeding.	96a	36bc	7b	7,271a	59ab	96ab
Potassium azide (G)	3.4	Postemergence, 20 days after seeding.	93a	40ab	10b	6,848cdefg	58bc	96ab
Sodium azide (G)	3.4	Postemergence, 20 days after seeding.	95a	43a	0b	7,029abcde	58bc	95b
Thiobencarb	1.1	Postemergence, 20 days after seeding.	90a	21f	0b	7,286a	55e	95b
Thiobencarb	2.2	Postemergence, 20 days after seeding.	94a	26ef	0b	7,056abcd	56cd	95b

See footnotes at end of table.

Table 23.—Experiment 6 (Stuttgart, 1975): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]—*Continued*

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury (%) 33 days after seeding	Injury (%) 70 days after seeding	Grain yield (kg/ha)	Head rice yield (%)	Germination (%)
Thiobencarb	3.4	Postemergence, 20 days after seeding.	95a	33c	10b	6,990abcde	57cd	95b
Propanil + thiobencarb	3.4 + 1.1	Postemergence, 20 days after seeding.	95a	26ef	0b	6,909bcdef	58bc	96ab
Propanil + thiobencarb	3.4 + 2.2	Postemergence, 20 days after seeding.	95a	26ef	0b	7,190ab	59ab	97a
None			0d	0g	0b	7,049abcd	58bc	95b

[1]'Starbonnet' rice seeded into floodwater April 23, emerged May 4. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast into flooded plots; other herbicides were applied in water sprays to drained plots. Plots were drained 1-2 days before applying sprays and reflooded 1-2 days after.

[3]See table 24 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, spikerush, and waterhyssop) were evaluated 70 days after seeding.

[5]Standard herbicide treatment.

Table 24.—Experiment 6 (Stuttgart, 1973-75): growth stage and height of rice and aquatic weeds at time of treatment

Time of treatment (days after seeding)	Rice: Growth stage	Rice: Height (cm)	Aquatic weeds[1]: Growth stage	Aquatic weeds[1]: Height (cm)
10	1-leaf	5	1-leaf	0.5
15	1-leaf	10	2-leaf	1.0
20	3-leaf	15	4-leaf	2.0

[1]Ducksalad, redstem, waterhyssop, and spikerush.

Tank mixtures of propanil and thiobencarb applied 15 or 20 days after seeding controlled more than 70% of the aquatic weeds in all years.

Granular potassium azide and sodium azide applied into the floodwater 15 and 20 days after seeding controlled aquatic weeds in all years.

The level of aquatic weed infestation in this experiment did not reduce grain yields greatly. Grain yields from untreated rice were good to excellent in all years, ranging from 5,880 to 8,186 kg/ha.

Grain quality (head rice yield and seed germination) did not differ significantly among treatments in 1973, but minor differences apparently not associated with specific herbicide treatments did exist in 1974 and 1975. Despite some differences in grain quality, quality was considered good to excellent from all treatments.

Experiment 7

A core of eight treatments was repeated in all years at the same rice and aquatic weed growth stages (tables 25-28). These were a standard treatment of propanil at 3.4 kg/ha applied to two-leaf aquatic weeds; granular thiobencarb at 1.1 and 2.2 kg/ha applied to one-leaf aquatics (10 to 15 days after seeding); granular thiobencarb at 2.2 and 3.4 kg/ha applied to two- and four-leaf aquatic weeds (15 to 20 and 20 to 25 days after seeding); and a sequential application of 3.4 kg/ha of propanil applied to two-leaf aquatics followed by 2.2 kg/ha of granular thiobencarb 5 days later.

Because preplanting applications of nitrofluorfen and bifenox injured rice moderately to severely and reduced grain yields in 1974, these treatments were not repeated in 1975 and 1976. In 1975 and 1976 the

(*Continued on page 40.*)

Table 25.—Experiment 7 (Stuttgart, 1974): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury[5] (%)	Grain yield (kg/ha)	Head rice yield[6] (%)	Germination[6] (%)
Nitrofluorfen	0.28	Preplant	20c	40d	4,894bc	55	93
Nitrofluorfen	0.56	Preplant	17c	47c	5,513bc	55	92
Bifenox	1.1	Preplant	0d	83a	1,631d	56	93
Thiobencarb (G)	1.1	Postemergence, 10 days after seeding	85a	0g	6,186a	58	95
Thiobencarb (G)	2.2	Postemergence, 10 days after seeding	93a	10f	6,322a	60	94
Propanil[7]	3.4	Postemergence, 15 days after seeding	45b	0g	5,968ab	53	94
Thiobencarb (G)	2.2	Postemergence, 15 days after seeding	97a	0g	6,273a	57	94
Thiobencarb (G)	3.4	Postemergence, 15 days after seeding	97a	0g	6,415a	58	95
Thiobencarb (G)	2.2	Postemergence, 20 days after seeding	87a	0g	6,243a	56	95
Thiobencarb (G)	3.4	Postemergence, 20 days after seeding	95a	23e	6,225a	55	93
Nitrofluorfen followed by thiobencarb	0.28; 2.2	Preplant; postemergence, 20 days after seeding	88a	63b	5,260bc	55	95
Bifenox followed by thiobencarb (G)	1.1; 2.2	Preplant; postemergence, 20 days after seeding	88a	83a	2,819c	58	95
Propanil followed by thiobencarb (G)	3.4; 2.2	Postemergence, 15 days after seeding; 20 days after seeding.	97a	23e	5,975ab	58	94
None			0d	0g	5,645abc	56	95

[1]'Starbonnet' rice seeded into floodwater April 23, germinated April 30, and emerged May 6. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast into flooded plots; other herbicides were applied in water sprays to drained plots.

[3]See table 28 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 70 days after seeding.

[5]Injury was evaluated 52 days after seeding.

[6]No values are significantly different (at the 5% level).

[7]Standard herbicide treatment.

Table 26.—Experiment 7 (Stuttgart, 1975): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury (%)		Grain yield[5] (kg/ha)	Head rice yield[5] (%)	Germination (%)
				33 days after seeding	70 days after seeding			
Thiobencarb (G)	1.1	Postemergence, 10 days after seeding.	95a	23a	0c	6,762	58	94c
Thiobencarb (G)	2.2	Postemergence, 10 days after seeding.	95a	33a	10b	6,262	58	95b
Propanil[6]	3.4	Postemergence, 15 days after seeding.	78ab	13b	0c	6,370	58	96a
Thiobencarb (G)	2.2	Postemergence, 15 days after seeding.	95a	33a	0c	6,358	56	94c
Thiobencarb (G)	3.4	Postemergence, 15 days after seeding.	95a	36a	0c	6,161	59	95b
Propanil + thiobencarb (G)	3.4+2.2	Postemergence, 15 days after seeding.	77ab	36a	40a	6,954	58	95b
Propanil + thiobencarb (G)	3.4+3.4	Postemergence, 15 days after seeding.	82ab	40a	40a	6,870	60	95b
Thiobencarb (G)	2.2	Postemergence, 20 days after seeding.	95a	36a	0c	6,792	59	96a
Thiobencarb (G)	3.4	Postemergence, 20 days after seeding.	95a	36a	10b	6,444	57	96a
Propanil[6]	3.4	Postemergence, 20 days after seeding.	63b	16b	0c	6,465	58	95b
Propanil + thiobencarb (G)	3.4+3.4	Postemergence, 20 days after seeding.	95a	30a	40a	6,383	57	96a
Propanil + thiobencarb (G)	6.7+6.7	Postemergence, 20 days after seeding.	95a	46a	40a	6,730	58	95b
Propanil followed by thiobencarb (G)	3.4; 2.2	Postemergence, 15 days after seeding; 20 days after seeding.	23c	30a	0c	6,405	59	95b
None			0d	0c	0c	6,339	59	94c

[1]'Starbonnet' rice seeded into floodwater April 23, germinated May 1, and emerged May 4. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast into flooded plots; other herbicides were applied in water sprays to drained plots.

[3]See table 28 for growth stages of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, spikerush, and waterhyssop) were evaluated 70 days after seeding.

[5]No values are significantly different (at the 5% level).

[6]Standard herbicide treatment.

Table 27.—Experiment 7 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Aquatic weed control[4] (%)	Injury (%)		Grain yield (kg/ha)	Head rice yield[5] (%)	Germination[5] (%)
				52 days after seeding	89 days after seeding			
Thiobencarb (G)	1.1	Postemergence, 15 days after seeding.	78a	33bc	17de	8,006ab	69	99
Thiobencarb (G)	2.2	Postemergence, 15 days after seeding.	94a	37bc	13de	8,335ab	69	97
Propanil[6]	3.4	Postemergence, 20 days after seeding.	30b	0d	0e	5,573d	65	99
Thiobencarb (G)	2.2	Postemergence, 20 days after seeding.	97a	27c	0e	8,140ab	69	99
Thiobencarb (G)	3.4	Postemergence, 20 days after seeding.	98a	27c	0e	8,520a	69	99
Propanil + thiobencarb	3.4+2.2	Postemergence, 20 days after seeding.	13bc	47ab	70a	5,800d	69	99
Propanil + thiobencarb	3.4+3.4	Postemergence, 20 days after seeding.	30b	50b	63a	6,082cd	70	99
Thiobencarb (G)	2.2	Postemergence, 25 days after seeding.	95a	30c	7e	7,854ab	69	99
Thiobencarb (G)	3.4	Postemergence, 25 days after seeding.	97a	27c	7e	7,947ab	69	100
Propanil[6]	3.4	Postemergence, 25 days after seeding.	13bc	0d	0e	7,114bc	69	99
Thiobencarb (G)	9.0	Postemergence, 25 days after seeding.	97a	77a	70a	7,115bc	69	99
Propanil + thiobencarb	3.4+3.4	Postemergence, 25 days after seeding.	73a	37bc	30cd	8,355ab	69	99
Propanil + thiobencarb	6.7+6.7	Postemergence, 25 days after seeding.	94a	50b	40bc	8,064ab	69	98
Propanil followed by thiobencarb (G)	3.4; 2.2	Postemergence, 20 days after seeding; 25 days after seeding.	98a	40bc	13de	7,928ab	69	99
None			0c	0d	0e	3,622e	65	98

[1]'Starbonnet' rice seeded into floodwater April 22, germinated May 5, and emerged May 11. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]Granular herbicides (G) were broadcast into flooded plots; other herbicides were applied in water sprays to drained plots.

[3]See table 28 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, spikerush, and waterhyssop) were evaluated 89 days after seeding.

[5]No values are significantly different (at the 5% level).

[6]Standard herbicide treatment.

Table 28.—Experiment 7 (Stuttgart, 1974-76): growth stage and height of rice and aquatic weeds at time of treatment

Time of treatment[1] (days after seeding)			Rice		Aquatic weeds[2]	
1974	1975	1976	Growth stage	Height (cm)	Growth stage	Height (cm)
10	10	15	1-leaf	3	1-leaf	0.5
15	15	20	1-leaf	8	2-leaf	1.0
20	20	25	3-leaf	15	4-leaf	2.0

[1]Because cool temperatures during the first weeks after seeding in 1976 slowed the growth of rice and weeds, herbicide application was delayed 5 days to permit plants to reach the desired growth stage and height.

[2]Ducksalad, redstem, spikerush, and waterhyssop.

following treatments were added: a standard treatment of propanil at 3.4 kg/ha applied to four-leaf aquatic weeds; tank mixtures of propanil and thiobencarb at 3.4+2.2 and 3.4+3.4 kg/ha applied to two-leaf aquatics (15 to 20 days after seeding), and propanil and thiobencarb at 3.4+3.4 and 6.7+6.7 kg/ha applied to four-leaf aquatics (20 to 25 days after seeding). Granular thiobencarb at 9.0 kg/ha applied 25 days after seeding was added in 1976.

Standard treatments of propanil gave poor to fair control of aquatic weeds that were in the two- to four-leaf stages in most years. In 1975, propanil controlled two-leaf aquatic weeds, but the aquatic weed population was so low that there was no loss in yield even in the unweeded plots. Propanil injured rice little, if any.

Granular thiobencarb, applied into the floodwater, controlled one- to four-leaf aquatic weeds in all years. Rates of 1.1 and 2.2 kg/ha controlled one-leaf aquatics, and 2.2 and 3.4 kg/ha controlled two- and four-leaf aquatic weeds. Rice in one- to three-leaf stages was injured slightly to moderately during the early season, but it recovered from most of the early injury by midseason. Thiobencarb at 9.0 kg/ha controlled the aquatic weeds in 1976, but it injured rice moderately to severely, and the injury persisted through midseason.

In 2 of 3 years, propanil followed by granular applications of thiobencarb controlled the aquatic weed complex, but this treatment failed to control aquatic weeds in 1975. This treatment injured rice slightly to moderately during the early season, but the crop recovered by midseason.

Tank mixtures of propanil and thiobencarb at rates of 3.4+2.2 and 3.4+3.4 kg/ha controlled two-leaf aquatic weeds in 1 of 2 years. Rice was injured moderately by these mixtures, and injury persisted through midseason. Propanil and thiobencarb at 3.4+3.4 and 6.7+6.7 kg/ha controlled four-leaf aquatic weeds both years, but rice was injured moderately.

Heavy infestations of aquatic weeds reduced grain yields only in 1976. Generally, rice receiving treatments that controlled aquatic weeds while causing slight to moderate crop injury yielded well. Rice receiving treatments that caused a high level of injury or gave poor to fair control of aquatic weeds yielded lower than the better performing treatments.

Head rice yields were not affected by any of the treatments, and germination of seed harvested from treated rice, was excellent (above 90%) in all years.

Experiment 8

Aquatic weeds and bearded sprangletop infested the plots in all years (tables 29-32). In 1976, barnyardgrass and broadleaf signalgrass also infested the plots. In 1977, spreading dayflower and eclipta, two broadleaf weeds, infested the plots at moderate population levels (about 20 plants/m^2). Because weed populations were higher in 1976 and 1977 than in 1978, grain yields from rice in the unweeded plots were reduced more during the first 2 years than during the last.

Standard treatments of propanil applied 20 or 25 days after seeding injured one- or two-leaf rice slightly to moderately. By midseason in 1977 and 1978, rice exhibited little, if any, injury from the standard propanil treatments. In 1976, however, rice treated at the one- and two-leaf stages exhibited moderate and slight injury, respectively, at mid-

(*Continued on page 45.*)

Table 29.—Experiment 8 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
			Aquatic weeds[4]	Grass weeds[5]	Bearded sprangle-top[6]	39 days after seeding	89 days after seeding			
Thiobencarb	4.5	Postemergence, 15 days after seeding.	96a	100a	99a	80a	37abc	7,938b	67	98
Propanil + thiobencarb	2.2+3.4	Postemergence, 15 days after seeding.	87ab	83a	100a	50b	20cde	8,113ab	67	98
Propanil + thiobencarb	3.4+3.4	Postemergence, 15 days after seeding.	87ab	90a	100a	40bc	20cde	7,968ab	68	98
Propanil[8]	2.2	Postemergence, 20 days after seeding.	33d	73a	33b	27c	57a	5,348f	67	98
Thiobencarb	4.5	Postemergence, 20 days after seeding.	53cd	96a	100a	43bc	30bcd	7,276abcde	69	98
Propanil + thiobencarb	2.2+3.4	Postemergence, 20 days after seeding.	68bc	93a	98a	40bc	37abc	7,027abcde	68	99
Propanil + thiobencarb	3.4+3.4	Postemergence, 20 days after seeding.	47cd	90a	83a	50b	47ab	6,496cdef	69	99
Propanil + bentazon	3.4+0.84	Postemergence, 20 days after seeding.	50cd	67a	23bc	33bc	47ab	6,418def	68	99
Propanil[8]	4.5	Postemergence, 25 days after seeding.	52cd	77a	77a	7d	30bcd	6,962abcde	67	98
Thiobencarb	4.5	Postemergence, 25 days after seeding.	93a	98a	95a	43bc	37abc	7,638abcd	68	99
Propanil + thiobencarb	2.2+3.4	Postemergence, 25 days after seeding.	93a	96a	100a	30c	0e	7,822abc	68	99
Propanil + thiobencarb	3.4+3.4	Postemergence, 25 days after seeding.	90a	100a	100a	43bc	23bcde	7,832abc	68	98
Propanil + thiobencarb	3.4+4.5	Postemergence, 25 days after seeding.	96a	98a	100a	40bc	30bcd	7,933ab	69	99
Propanil + thiobencarb	6.7+6.7	Postemergence, 25 days after seeding.	98a	98a	100a	50b	7de	8,145a	68	94
Propanil + bentazon	3.4+0.84	Postemergence, 25 days after seeding.	80ab	97a	82a	0d	33abc	7,171abcde	68	99
Propanil + bentazon	3.4+0.84	Postemergence, 35 days after seeding.	55cd	96a	40b	7d	40abc	6,728bcde	68	99
Propanil + 2,4,5-T	3.4+0.84	Postemergence, 35 days after seeding.	43d	96a	40b	0d	43abc	4,936ef	68	99
Molinate + bentazon	3.4+0.84	Postemergence, 35 days after seeding.	40d	78a	17bc	10d	43abc	6,140ef	68	98

See footnotes at end of table.

Table 29.—Experiment 8 (Stuttgart, 1976): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]—*Continued*

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
			Aquatic weeds[4]	Grass weeds[5]	Bearded sprangle-top[6]	39 days after seeding	89 days after seeding			
Molinate + 2,4,5-T	3.4+0.84	Postemergence, 35 days after seeding.	55cd	90a	33b	0d	37abc	6,206ef	68	99
None			0e	0b	0c	0d	0e	2,006g	66	97

[1]'Starbonnet' rice seeded into floodwater April 22, emerged May 11. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]All treatments were applied as sprays to drained plots.

[3]See table 32 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, spikerush, and waterhyssop) were evaluated 33 days after seeding.

[5]Grass weed complex (barnyardgrass, bearded sprangletop, and broadleaf signalgrass) was evaluated 39 days after seeding. In the early ratings, grass species were not tallied separately; there were bearded sprangletop plants present but they did not develop sufficiently to allow valid comparisons until midseason to late season.

[6]Bearded sprangletop was evaluated 88 days after seeding.

[7]No values are significantly different (at the 5% level).

[8]Standard herbicide treatment.

Table 30.—Experiment 8 (Stuttgart, 1977): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)			Injury (%)		Grain yield (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
			Aquatic weeds[4]	Broadleaf weeds[5]	Bearded sprangle-top[6]	27 days after seeding	43 days after seeding			
Thiobencarb	4.5	Postemergence, 15 days after seeding.	93a	98a	98a	40ab	27abc	7,512a	60	97
Propanil + thiobencarb	2.2+3.4	Postemergence, 15 days after seeding.	95a	97a	100a	37abc	7ef	7,111ab	62	97
Propanil + thiobencarb	3.4+3.4	Postemergence, 15 days after seeding.	95a	96a	98a	33bc	10def	6,961ab	61	96
Propanil[8]	2.2	Postemergence, 20 days after seeding.	80c	80d	23d	17ef	0f	6,728ab	61	96
Thiobencarb	4.5	Postemergence, 20 days after seeding.	88abc	98a	92a	30cd	23abcd	7,652a	62	98

Propanil + thiobencarb	2.2+3.4	Postemergence, 20 days after seeding.	93a	98a	93a	40ab	13cdef	7,518a	58	98
Propanil + thiobencarb	3.4+3.4	Postemergence, 20 days after seeding.	95a	98a	88ab	43a	23abcd	7,680a	61	96
Propanil + bentazon	3.4+0.84	Postemergence, 20 days after seeding.	92ab	90abc	30d	13f	0f	7,452a	61	96
Propanil[8]	4.5	Postemergence, 25 days after seeding.	83bc	85bcd	20d	17ef	0f	7,144ab	62	97
Thiobencarb	4.5	Postemergence, 25 days after seeding.	88abc	98a	75bc	22de	20f	7,261ab	58	97
Propanil + thiobencarb	2.2+3.4	Postemergence, 25 days after seeding.	87abc	97a	65c	30cd	13cdef	5,550b	62	97
Propanil + thiobencarb	3.4+3.4	Postemergence, 25 days after seeding.	87abc	82cd	30d	17ef	10def	6,691ab	61	95
Propanil + thiobencarb	3.4+4.5	Postemergence, 25 days after seeding.	95a	98a	93a	33bc	27abc	7,501a	59	96
Propanil + thiobencarb	6.7+6.7	Postemergence, 25 days after seeding.	95a	98a	100a	40ab	37a	7,658a	62	96
Propanil + bentazon	3.4+0.84	Postemergence, 25 days after seeding.	92ab	94a	20d	15f	0f	7,148ab	62	97
Propanil + bentazon	3.4+0.84	Postemergence, 35 days after seeding.	90ab	98a	23d	0g	0f	7,272ab	61	97
Propanil + 2,4,5-T	3.4+0.84	Postemergence, 35 days after seeding.	93a	98a	23d	0g	37a	7,212ab	60	96
Molinate + bentazon	3.4+0.84	Postemergence, 35 days after seeding.	88abc	98a	17d	0g	0f	7,404ab	61	97
Molinate + 2,4,5-T	3.4+0.84	Postemergence, 35 days after seeding.	83bc	93ab	27d	0g	33ab	6,828ab	61	97
None			0d	0e	0e	0g	0f	3,136c	57	96

[1]'Starbonnet' rice seeded into floodwater April 19, emerged May 2. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]All treatments were applied as sprays to drained plots.

[3]See table 32 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 43 days after seeding.

[5]Broadleaf weeds (eclipta and spreading dayflower) were evaluated after rice had matured.

[6]Bearded sprangletop was evaluated 64 days after seeding.

[7]No values are significantly different (at the 5% level).

[8]Standard herbicide treatment.

Table 31.—Experiment 8 (Stuttgart, 1978): influence of herbicide treatment on weed control, crop injury, grain yield, head rice yield, and germination of water-seeded paddy rice[1]

Herbicide[2]	Rate (kg/ha)	Time applied[3]	Weed control (%)		Injury[6] (%)	Grain yield[7] (kg/ha)	Head rice yield[7] (%)	Germination[7] (%)
			Aquatic weeds[4]	Bearded sprangletop[5]				
Thiobencarb	4.5	Postemergence, 15 days after seeding	10d	95a	0c	6,640	61	96
Propanil + thiobencarb	2.2+3.4	Postemergence, 15 days after seeding	13d	98a	0c	5,425	59	96
Propanil + thiobencarb	3.4+3.4	Postemergence, 15 days after seeding	57abc	99a	0c	5,919	60	97
Propanil[8]	2.2	Postemergence, 20 days after seeding	0d	7c	9b	5,597	61	97
Thiobencarb	4.5	Postemergence, 20 days after seeding	37bcd	88ab	0c	6,170	60	96
Propanil + thiobencarb	2.2+3.4	Postemergence, 20 days after seeding	20cd	78b	0c	5,439	60	96
Propanil + thiobencarb	3.4+3.4	Postemergence, 20 days after seeding	23cd	88ab	0c	6,649	61	96
Propanil + bentazon	3.4+0.84	Postemergence, 20 days after seeding	0d	7c	0c	4,273	61	96
Propanil[8]	4.5	Postemergence, 25 days after seeding	23cd	0c	0c	5,646	63	97
Thiobencarb	4.5	Postemergence, 25 days after seeding	57abc	83ab	0c	4,801	64	96
Propanil + thiobencarb	2.2+3.4	Postemergence, 25 days after seeding	73ab	83ab	0c	6,036	61	97
Propanil + thiobencarb	3.4+3.4	Postemergence, 25 days after seeding	60abc	93a	0c	5,555	58	95
Propanil + thiobencarb	3.4+4.5	Postemergence, 25 days after seeding	73ab	94a	10b	6,366	59	96
Propanil + thiobencarb	6.7+6.7	Postemergence, 25 days after seeding	83a	98a	23a	5,675	59	95
Propanil + bentazon	3.4+0.84	Postemergence, 25 days after seeding	27d	0c	0c	5,474	62	96
Propanil + bentazon	3.4+0.84	Postemergence, 35 days after seeding	13d	7c	0c	5,289	63	97
Propanil + 2,4,5-T	3.4+0.84	Postemergence, 35 days after seeding	0d	7c	0c	5,624	62	95
Molinate + bentazon	3.4+0.84	Postemergence, 35 days after seeding	13d	0c	0c	5,422	61	96
Molinate + 2,4,5-T	3.4+0.84	Postemergence, 35 days after seeding	27cd	0c	0c	5,054	61	96
None			0d	0c	0c	5,414	64	96

[1]'Starbonnet' rice seeded into floodwater April 21, emerged May 3. Values within a column followed by the same letter are not significantly different (using Duncan's multiple-range test at the 5% level).

[2]All treatments were applied as sprays to drained plots.

[3]See table 32 for growth stage of rice and weeds at time of treatment.

[4]Aquatic weeds (ducksalad, redstem, and waterhyssop) were evaluated 86 days after seeding.

[5]Bearded sprangletop was evaluated 91 days after seeding.

[6]Injury ratings were made 73 days after seeding.

[7]No values are significantly different (at the 5% level).

[8]Standard herbicide treatment.

Table 32.--Experiment 8 (Stuttgart, 1976-78): growth stage and height of rice and weeds at time of treatment[1]

Time of treatment (days after seeding)	Rice		Aquatic weeds[2]		Bearded sprangletop	
	Growth stage	Height (cm)	Growth stage	Height (cm)	Growth stage	Height (cm)
15	1-leaf	3	1-leaf	0.5	1-leaf	0.5
20	1-leaf	8	2-leaf	1.0	2-leaf	1.0
25	2-leaf	13	4-leaf	2.0	4-leaf	5.0
35	tillering	20	6-leaf	3.0	tillering	15.0

[1]In 1976, barnyardgrass and broadleaf signalgrass infested the plots in addition to bearded sprangletop; both grasses were in the same stage as bearded sprangletop for each time of application. In 1977, spreading dayflower and eclipta (broadleaf weeds) also infested the plots; they were in the 1-, 2-, 4-, and 6-leaf stages (or 2.5, 5.0, 7.5, and 10.0 cm tall), respectively, on the successive treatment days.

[2]Ducksalad, redstem, spikerush, and waterhyssop.

season. Standard propanil treatments gave varied levels of weed control during the 3-year period, ranging from none to good. In all years, 2.2 kg/ha of propanil failed to control two-leaf bearded sprangletop, and in 2 of 3 years 4.5 kg/ha failed to control four-leaf bearded sprangletop.

Thiobencarb applied 15 days after seeding at 4.5 kg/ha controlled the aquatic weed complex in 2 of 3 years and controlled bearded sprangletop in all years. This treatment also gave excellent control of the grass weed complex in 1976 and the broadleaf weed complex of spreading dayflower and eclipta in 1977. In 1976, this treatment caused severe early injury to one-leaf rice and moderate injury to older rice, but the rice recovered from most of the injury by midseason. Slight to moderate temporary rice injury was observed in 1977, and no injury was observed in 1978. Despite the occurrence of injury, rice yields were not affected.

Thiobencarb applied 20 days after seeding at 4.5 kg/ha controlled aquatic weeds only in 1 of 3 years but controlled bearded sprangletop in all years. It also controlled the early grass weed complex in 1976 and the broadleaf weed complex in 1977. Although slight rice injury from this treatment was still evident at midseason in 1976 and 1977, it did not cause yield reductions.

Thiobencarb applied 25 days after seeding at 4.5 kg/ha controlled aquatic weeds in 2 of 3 years and bearded sprangletop in all years. This treatment controlled the early grass weed complex in 1976 and the broadleaf weed complex in 1977. It injured rice only moderately and did not reduce yields.

Tank mixtures of propanil and thiobencarb applied 15 to 25 days after seeding generally gave good to excellent control of bearded sprangletop in the one- to four-leaf stages. However, in 1977 rates of 2.2+3.4 and 3.4+3.4 kg/ha applied 25 days after seeding gave only poor to fair control. Tank mixtures of propanil and thiobencarb controlled aquatic weeds less consistently than they controlled bearded sprangletop. Applications at 15 days after seeding gave good to excellent aquatic weed control in 2 of 3 years. Applications at 20 days after seeding gave excellent aquatic weed control in 1977 but only poor to fair control in 1976 and 1978. In 1976 propanil-thiobencarb mixtures controlled the grass weed complex, and in 1977 they controlled the broadleaf weed complex. Applications at 25 days after seeding gave fair to excellent control of aquatic weeds all 3 years. Propanil-thiobencarb tank mixtures injured rice no more than moderately, and the rice usually recovered by midseason.

A tank mixture of propanil and bentazon applied at 3.4+0.84 kg/ha 20 days after seeding gave fair control of the early-season grass weed complex in 1976 and gave excellent control when applied 25 or 35 days after seeding. Except for applications 25 days after seeding in 1976, poor control of bearded sprangletop was obtained regardless of when the mixture was applied. Propanil-bentazon gave excellent control of broadleaf weeds in 1977 whenever applied. Aquatic weed control with the propanil-bentazon tank mixture ranged from none to good, with the poorest control in 1978 and the best in 1977. No association was evident between time of application and performance, and propanil-bentazon tank mixtures caused no more than moderate injury to rice.

A tank mixture of molinate and bentazon applied at 3.4+0.84 kg/ha 35 days after seeding controlled aquatic weeds in 1 of 3 years but failed to control bearded sprangletop anytime during the 3-year period. In 1977, this mixture gave excellent control of the broadleaf weed complex of spreading dayflower and eclipta, and early control of the grass weed complex. This mixture caused no more than moderate rice injury.

A tank mixture of 3.4+0.84 kg/ha of propanil and 2,4,5-T applied 35 days after seeding controlled aquatic weeds in 1 of 3 years and failed to control bearded sprangletop any of the 3 years. It gave early control of the grass weed complex in 1976 and controlled the broadleaf weed complex in 1977. Rice treated with this mixture showed only moderate injury.

A tank mixture of molinate and 2,4,5-T applied at 3.4+0.84 kg/ha 35 days after seeding controlled aquatic weeds 1 of 3 years, failed to control bearded sprangletop in any of the 3 years, and controlled the grass weed and broadleaf weed complexes in 1976 and 1977, respectively. Rice so treated exhibited no more than moderate injury.

Rice receiving treatments that controlled aquatic weeds and bearded sprangletop best usually produced highest grain yields. Rice quality was excellent from all plots; no treatment reduced either head rice yield or seed germination.

DISCUSSION

Dry-Seeded Rice

Standard treatments

Propanil or molinate are considered the standard herbicides because they are used on most of the rice grown in the United States (U.S. Department of Agriculture-States-U.S. Environmental Protection Agency 1979). They are applied postemergence alone, in tank mixtures, or in sequence (Arkansas Cooperative Extension Service 1979). The results reported herein with standard propanil and molinate treatments alone or in combinations in weed control programs agree with other research results (Smith 1977a, Smith et al. 1977, Eastin and Helpert 1979).

A standard treatment of propanil at 4.5 kg/ha consistently controlled four-leaf barnyardgrass and such susceptible broadleaf weeds as eclipta and hemp sesbania but frequently failed to control bearded and tighthead sprangletop, spreading dayflower, and the aquatic weed complex of duck-salad, redstem, and waterhyssop. This standard treatment also failed to control barnyardgrass and other susceptible weeds when grass plants were subjected to moisture and temperature stresses before application. A standard treatment of granular molinate applied postemergence into the floodwater consistently controlled four-leaf to tillering barnyardgrass but gave inconsistent control of bearded sprangletop and the aquatic-broadleaf weed complexes.[6] Although standard treatments of propanil and molinate injured rice slightly to moderately soon after application, the rice recovered from the early injury by midseason. Applying floodwater within 1 week after propanil treatment prevented reinfestations of barnyardgrass but increased problems with aquatic weeds.

An early application of propanil controlled two-leaf barnyardgrass, but grass plants that germinated after treatment reinfested the crop and frequently reduced grain yields. To control these weeds, a second application of propanil, applied 1 to 2 weeks after the first and just before applying a permanent flood to the crop, was needed. Timely application of floodwater after the second treatment prevented reinfestations of barnyardgrass. Because propanil exhibited no residual activity, grass and broadleaf weeds germinated after application, and aquatic weeds germinated and infested the crop as soon as the rice was flooded. When all barnyardgrass plants had emerged by the time of the first propanil application, a second treatment was not required.

A tank mixture of propanil and molinate controlled barnyardgrass (four-leaf stage), bearded sprangletop (up to 1.3 cm tall), and spreading dayflower or eclipta (up to 2.5 cm tall) better than single treatments of propanil or molinate. Flooding the crop within a week after applying the mixture prevented reinfestations of grass and broadleaf weeds. The residual or preemergence activity of this mixture was no better than a standard propanil treatment; aquatic weeds germinated and infested the crop after permanent flooding. These results confirm those of Smith (1974).

A sequential treatment of propanil applied to

[6]Emulsifiable formulations of molinate applied as sprays to soil surfaces vaporize and are rapidly lost (Smith et al. 1977).

two-leaf barnyardgrass followed by granular molinate applied after permanent flooding controlled barnyardgrass. The propanil component killed the two-leaf grass plants, and molinate killed the grass plants that emerged after propanil application. However, this treatment failed to control spreading dayflower or the aquatic weed complex.

A sequential treatment of a propanil-molinate tank mixture applied to two-leaf barnyardgrass and followed by granular molinate after permanent flooding controlled barnyardgrass, bearded and tighthead sprangletop, and eclipta. The tank mixture controlled two-leaf barnyardgrass, bearded and tighthead sprangletop (up to 1.3 cm tall), and eclipta (up to 2.5 cm tall) better than single treatments of propanil or molinate. The granular molinate applied into the floodwater controlled the grass-broadleaf weed complex that emerged after applying the herbicide mixture. Of course, this treatment gave no residual control of aquatic weeds that germinated after permanent flooding.

Propanil applied after most of the grass plants emerged controlled barnyardgrass with one to four leaves. (Molinate applied after rice becomes large enough to tolerate floodwater controls barnyardgrass that is in the one-leaf to tillering stages of growth.) However, propanil or molinate alone frequently failed to control bearded and tighthead sprangletop; the aquatic weed complex of ducksalad, redstem, and waterhyssop; and some of the more resistant broadleaf weeds such as spreading dayflower. The use of propanil and molinate in treatment programs such as tank mixtures or as sequential treatments, improved control of tolerant weeds such as bearded and tighthead sprangletop and spreading dayflower as well as susceptible barnyardgrass but did nothing to control the aquatic weed complex.

Tank mixtures

Early postemergence applications of tank mixtures that combined propanil with preemergence or residually active herbicides improved control of the grass-broadleaf-aquatic weed complexes compared with standard treatments of propanil or molinate, alone or in treatment programs. Such tank mixtures controlled small barnyardgrass (two-leaf), bearded and tighthead sprangletop (up to 1.3 cm tall), eclipta, and spreading dayflower (up to 2.5 cm tall); they gave residual control of the grass-broadleaf weed complex for 3 to 5 weeks after application; and they controlled the aquatic weed complex (ducksalad, redstem and waterhyssop) that germinated after permanent flooding.

Some of the residual herbicides that were mixed with propanil were more effective than others. Tank mixtures of propanil with butachlor, oxadiazon, or thiobencarb were the most effective for controlling the aquatic-broadleaf-grass weed complexes. They usually controlled the weed complexes better than single treatments of butachlor, oxadiazon, or thiobencarb applied preemergence or postemergence. Although all three of these residual herbicides gave good to excellent control of the aquatic-broadleaf-grass weed complexes, propanil-oxadiazon and propanil-butachlor controlled the aquatic weed complex more consistently than propanil-thiobencarb. The most effective rates of these tank mixtures from standpoints of weed control and crop tolerance were propanil-butachlor at 3.4+2.8 and 3.4+3.4 kg/ha; propanil-oxadiazon at 2.2+0.84, 3.4+0.84, and 3.4+1.1 kg/ha; and propanil-thiobencarb at 3.4+3.4 kg/ha. Propanil-butachlor and propanil-oxadiazon applied at the higher rate ranges were slightly more effective in experiments on Perry clay than on Crowley silt loam. Several previous reports indicated that these mixture treatments performed well (Smith 1970, Derting et al. 1971, Helpert and Eastin 1975, Hogue 1976, LeClair 1977, Smith 1977a).

Plots did not need to be flooded soon after these mixture treatments because the residual herbicide component in the mixture prevented weed reinfestations for 3 to 5 weeks after application. However, moisture from rain or irrigation was required to activate the preemergence herbicide component (results that agree with those reported by Smith 1975).

Herbicide mixtures that performed less effectively than those mentioned above were mixtures of propanil and bifenox and propanil and butralin. Propanil-bifenox gave inconsistent control of the aquatic-broadleaf-grass weed complexes, a less effective performance than that reported by Eastin and Helpert (1979). Although propanil-butralin controlled barnyardgrass consistently, this mixture frequently failed to control the aquatic-broadleaf weed complexes. Nevertheless, propanil-butralin tank mixtures applied postemergence frequently controlled weeds better than butralin applied alone preemergence. (Preemergence applications of butralin controlled barnyardgrass less effectively in this study than in research reported by Szilvassy in 1979.)

Sequential treatments

Sequential applications of two herbicides controlled the aquatic-broadleaf-grass weed complexes better than propanil or molinate used alone or in treatment programs, but sequential treatments usually controlled weeds less effectively and consistently, and frequently injured rice more than herbicide mixtures applied early postemergence.

Preemergence applications of several herbicides followed by standard treatments of propanil or molinate varied in control of weeds and damage to rice. Usually, residually active herbicides injured rice more when applied preemergence than when applied postemergence in tank mixtures with propanil or in sequence with either propanil or molinate. However, the crop usually recovered from this early injury by midseason (50 to 70 days after seeding).

Preemergence herbicide treatments that controlled the aquatic-broadleaf-grass weed complexes and injured rice only slightly to moderately included oxadiazon, butachlor, thiobencarb, and bifenox. Of these four, oxadiazon usually gave the most consistent and best residual control of the aquatic weed complex; it was followed by bifenox, butachlor, and thiobencarb, in order of diminishing performance. These four residual herbicides applied sequentially with propanil or molinate frequently controlled other weeds including bearded and tighthead sprangletop, eclipta, and spreading dayflower better than preemergence treatments of the same herbicides alone or standard propanil or molinate applications. When these four herbicides were applied preemergence alone, bifenox controlled barnyardgrass least. Therefore, standard applications of propanil or molinate were more essential for control of barnyardgrass after preemergence applications of bifenox than those of oxadiazon, butachlor, or thiobencarb. Even so, standard propanil or molinate applications were usually necessary after preemergence applications of oxadiazon, butachlor, or thiobencarb for complete control of weeds. Rates that controlled and did not injure rice severely were: 0.84 to 1.1 kg/ha for oxadiazon, 3.4 kg/ha for bifenox, 3.4 kg/ha for butachlor, and 4.5 kg/ha for thiobencarb. Emulsifiable, wettable powder, and flowable formulations of bifenox applied preemergence and combined with standard propanil or molinate treatments performed well. Other research has also indicated that sequential treatments with bifenox, butachlor, oxadiazon, or thiobencarb applied preemergence and followed by standard propanil applications control weeds without severe rice injury (Derting et al. 1971, Palmer and Helpert 1974, Dean et al. 1976, Hogue 1976, Dean and Dreger 1977, Smith 1977a, Eastin and Helpert 1979).

A sequential treatment of butralin applied preemergence and followed by a standard application of propanil controlled barnyardgrass but frequently failed to control aquatic weeds. And although oxyfluorfen applied preemergence and followed by a standard treatment of propanil usually controlled barnyardgrass and bearded sprangletop, it was less consistent in controlling aquatic weeds than oxadiazon, butachlor, bifenox, or thiobencarb applied in the same sequence.

Standard applications of either propanil or molinate followed by bentazon applied to plots drained after aquatic weeds emerged controlled barnyardgrass and the aquatic weed complex of ducksalad, redstem, and waterhyssop. A rate of 0.84 kg/ha of bentazon controlled the aquatics, and the propanil or molinate controlled the barnyardgrass. These treatments failed to control bearded sprangletop; propanil, molinate, and bentazon have also failed to control bearded sprangletop (Smith et al. 1977, Atwell et al. 1978). Spreading dayflower was seldom present in our plots, but it has been controlled by postemergence applications of bentazon (Daniel 1974, Palmer and Helpert 1974).

Standard applications of propanil or molinate followed by granular thiobencarb or bifenox applied just before or just after permanent flooding controlled barnyardgrass, spreading dayflower, and the aquatic weed complex of ducksalad, redstem, and waterhyssop. The propanil or molinate controlled barnyardgrass; the bifenox or thiobencarb controlled emerged aquatic weeds and those that germinated after application and also improved the control of spreading dayflower and bearded sprangletop. Standard rates of propanil or molinate combined with 2.2 kg/ha of either granular thiobencarb or bifenox controlled weeds without injuring the crop. In other studies, granular bifenox applied into the floodwater after standard treatments of propanil controlled aquatic weeds selectively in rice (Dean et al. 1976).

Standard treatments of propanil followed by granular nitrofluorfen or oxyfluorfen applied just before permanent flooding controlled barnyardgrass, spreading dayflower, and the aquatic weed complex of ducksalad, redstem, and waterhyssop;

the propanil controlled barnyardgrass, and the nitrofluorfen or oxyfluorfen controlled spreading dayflower and aquatic weeds. Propanil followed by oxyfluorfen performed better on silt loam than on clay soil. Oxyfluorfen did not enhance control of bearded or tighthead sprangletop, compared with propanil alone. Nitrofluorfen at rates of 0.28 and 0.56 kg/ha controlled aquatic weeds; 0.28 kg/ha did not injure rice, but 0.56 kg/ha did. Oxyfluorfen at 0.22 kg/ha controlled aquatic weeds with minimum rice injury.

Standard treatments of propanil followed by triclopyr applied after aquatic weeds emerged failed to control ducksalad, redstem, and waterhyssop. The propanil component usually controlled barnyardgrass, but triclopyr did not improve control of aquatic weeds, spreading dayflower, or eclipta over a single treatment of propanil. Triclopyr caused slight injury to rice (chlorosis of plants) at 0.28 kg/ha, but the rice recovered by midseason.

Granular nitrofluorfen (at 0.28 and 0.56 kg/ha) or oxyfluorfen (at 0.22 kg/ha) applied just before permanent flooding and followed by standard treatments of molinate applied just after flooding injured rice while controlling barnyardgrass, bearded sprangletop, and aquatic weeds. The rice usually recovered from the injury by midseason.

A sequential treatment of oxyfluorfen applied preemergence (at 0.28 kg/ha) followed by an early postemergence treatment of thiobencarb (at 4.5 kg/ha) controlled barnyardgrass, bearded sprangletop, and aquatic weeds without undue injury to rice.

Water-Seeded Rice

Standard treatments

Propanil, 2,4,5-T, or 2,4-D are considered standard herbicides in commercial weed control programs in water-seeded rice (Smith et al. 1977, Smith 1979). Propanil applied during the early season controls barnyardgrass and other susceptible grass and broadleaf weeds, but it fails to control the aquatic weed complex and such tolerant grass weeds as sprangletop species. The phenoxy herbicides, 2,4,5-T and 2,4-D applied at midseason, control broadleaf-aquatic weed complexes. Because aquatic weeds compete with rice during the early season, 2,4,5-T may be applied 3 to 6 weeks after rice emergence to suppress growth of these weeds. However, it frequently fails to control aquatic weeds (especially ducksalad), even when applied to small weed plants. Also, after early season applications of 2,4,5-T, aquatic weeds may reinfest the crop and compete with rice. Although 2,4-D applied 3 to 6 weeks after rice emergence controls aquatic weeds (including ducksalad), it injures seedling rice plants severely (Smith et al. 1977).

In these experiments, standard treatments of propanil or 2,4,5-T applied early in the season (2 to 3 weeks after seeding) consistently failed to control the aquatic weed complex, results that confirm previous research (Smith 1977b).

Single herbicide treatments

Thiobencarb applied 10 to 25 days after rice was water-seeded controlled aquatic weeds 0.5 to 2 cm tall. Both the emulsifiable formulation sprayed on drained plots and the granular formulation applied into the floodwater were effective; they controlled aquatic weeds better than standard treatments of propanil or 2,4,5-T. They also controlled grass weeds (such as barnyardgrass, bearded sprangletop, and broadleaf signalgrass) and broadleaf weeds (such as spreading dayflower and eclipta) better than standard propanil treatments. Thiobencarb controlled both emerged weeds and those that germinated for several weeks after application. Thiobencarb injured one-leaf plants more than two- or four-leaf rice plants. Rates of 2.2 to 4.5 kg/ha controlled weeds better than 1.1 kg/ha, but 4.5 kg/ha injured rice more than lower rates. Considering both weed control and crop tolerance, the optimum rate was 3.4 kg/ha applied after the crop stand was established (two- to four-leaf stages). Our results concur with earlier reports (Smith 1977b) that thiobencarb controls aquatic weeds selectively in water-seeded rice.

Granular potassium azide and sodium azide applied postemergence into the floodwater 15 to 20 days after seeding controlled the aquatic weed complex of ducksalad, redstem, spikerush, and waterhyssop. These herbicides controlled weeds in the two- to four-leaf stages (up to 1 to 2 cm tall) without severe injury to one-leaf rice (at least 10 cm tall). A rate of 3.4 kg/ha of either herbicide controlled weeds and did not permanently injure rice. Our results with potassium azide and sodium azide agree with previous research (Newman 1976, Smith 1977b).

Preplant treatments of nitrofluorfen or bifenox injured water-seeded rice and failed to control aquatic weeds.[7]

Tank mixtures

Tank mixtures of herbicides applied early postemergence controlled aquatic weeds with only slight to moderate rice injury. A tank mixture of propanil and thiobencarb controlled aquatic weeds better than such other mixtures as propanil and 2,4,5-T, propanil and bentazon, molinate and 2,4,5-T, or molinate and bentazon. Propanil-thiobencarb applied 15 to 25 days after seeding controlled aquatic weeds in the one- to four-leaf stages (0.5 to 2 cm tall) and bearded sprangletop, barnyardgrass, and broadleaf signalgrass in the one- to four-leaf stages (0.5 to 5 cm tall). This treatment frequently injured rice moderately during the early season, but the crop outgrew most of the injury by midseason and produced excellent grain yields and quality. When cool temperatures delayed germination and growth of rice, delaying treatment until rice plants became rooted in the soil improved safety to the crop. Optimum rates for this mixture were 3.4 kg/ha of propanil and 2.2 to 3.4 kg/ha of thiobencarb. Earlier reports (Smith 1977b) showed that propanil and thiobencarb applied early postemergence controlled aquatic weeds and caused only slight to moderate injury to water-seeded rice.

A tank mixture of propanil and bentazon applied at 3.4+0.84 kg/ha 20 to 35 days after seeding gave erratic control of aquatic weeds, especially ducksalad. The optimum time of application was 25 days after seeding, when aquatic weeds had four leaves (2 cm tall). This mixture controlled spreading dayflower, eclipta, barnyardgrass, and broadleaf signalgrass but usually failed to control bearded sprangletop. Rice in the one-leaf to tillering stages was injured moderately during the early season, but the crop outgrew most of the injury by midseason and produced good grain yields when weeds were controlled. Other research indicated that tank mixtures of propanil and bentazon applied early postemergence controlled ducksalad, redstem, and barnyardgrass (Cole et al. 1977, Atwell et al. 1978).

Tank mixtures of propanil and 2,4,5-T, molinate and 2,4,5-T, and molinate and bentazon gave inconsistent control of aquatic weeds, especially ducksalad. They controlled barnyardgrass, broadleaf signalgrass, eclipta, and spreading dayflower but failed to control bearded sprangletop. Rates that controlled these grass-broadleaf weeds were 3.4 kg/ha of propanil or molinate mixed with 0.84 kg/ha of 2,4,5-T or bentazon. These mixtures did not injure rice permanently. Other research indicated that propanil and 2,4,5-T applied early postemergence controlled aquatic weeds selectively in rice (Smith 1973).

Sequential treatments

Standard treatments of propanil at 3.4 kg/ha followed by 2.2 kg/ha of granular thiobencarb applied into the floodwater 20 to 25 days after seeding controlled the aquatic weed complex of ducksalad, redstem, spikerush and waterhyssop. The thiobencarb controlled four-leaf aquatic weeds that were 1 cm tall. This sequential treatment controlled aquatic weeds better than a single treatment of propanil and equally as well as a single treatment of granular thiobencarb applied at the same rate. And although the addition of propanil did not improve control of aquatics, it may improve control of barnyardgrass. These results agree with earlier reports (Smith 1977b).

Sequential treatments of nitrofluorfen at 0.28 kg/ha or bifenox at 1.1 kg/ha applied preplant, followed by granular thiobencarb at 2.2 kg/ha applied into the floodwater 20 days after seeding, injured rice moderately to severely and reduced grain yields even though they controlled the aquatic weeds. Nitrofluorfen and bifenox injured the crop more than thiobencarb.

[7]Bifenox is recommended only for dry-seeded rice because of the amount of injury it causes water-seeded rice (Arkansas Cooperative Extension Service 1979).

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APPENDIX.—SCIENTIFIC NAMES OF PLANTS DISCUSSED IN THIS PUBLICATION

Common name	Scientific name
Barnyardgrass	*Echinochloa crus-galli* (L.) Beauv.
Bearded sprangletop	*Leptochloa fascicularis* (Lam.) Gray.
Dayflower	*Commelina* spp.
Ducksalad	*Heteranthera limosa* (Sw.) Willd.
Eclipta	*Eclipta alba* (L.) Hassk.
False pimpernel	*Lindernia anagallidea* (Michx.) Pennell.
Hemp sesbania	*Sesbania exaltata* (Raf.) Cory.
Knotgrass	*Paspalum distichum* L.
Morningglory	*Ipomoea* spp.
Panicum	*Panicum* spp.
Pondweed	*Potamogeton* spp.
Redstem	*Ammannia auriculata* Willd.
Rice	*Oryza sativa* L.
Smartweed	*Polygonum* spp.
Spikerush	*Eleocharis* spp.
Sprangletop	*Leptochloa* spp.
Spreading dayflower	*Commelina diffusa* Burm. f.
Tighthead sprangletop	*Leptochloa panicoides* (Presl) Hitchc.
Umbrellasedge	*Cyperus* spp.
Waterhyssop	*Bacopa rotundifolia* (Michx.) Wettst.
Waterprimrose	*Jussiaea* spp.
Willowleaf morningglory	*Ipomoea wrightii* Gray.

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